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## THE PRESENT STATUS OF AGRICULTURE IN THE UNITED STATES*

JOHN D. BLACK†
*Harvard University, Cambridge, Mass.*

The purpose of this paper is to describe the economic conditions of agriculture in the United States. It ought to be a task that could be performed in the spirit of true scientific objectivity. Yet if one were to discuss the matter even with men commonly called economists in the United States, one would discover a wide difference in the descriptions. So far as the public is concerned, the Republican newspapers in the East are saying that agriculture has fully recovered from its depression, and that the agitation for further farm relief is being continued for purely political reasons. Leaders of the "farm bloc" in Congress and farm journals in the Central and Western states are insisting that farm people are almost as sorely distressed as in 1921 and 1922, and some go so far as to say that the farmers are still falling behind financially, and that unless strong measures are soon taken, our farm people will sink "to the awful condition of the European peasants." What this condition is, few of them understand, but nevertheless it has figured prominently as the "horrible example" in much of the current discussion of the agricultural problem. In the following account, I am going to present the facts as objectively as possible in the form of the best data available as to the relative prices received for farm products, physical volume of production, gross income or total value of product, prices paid by farmers for goods and services bought, net income, wages of farm labor, taxes paid by farmers, farm mortgage indebtedness, land rents and land values, and movements of farm population. It must be pointed out in advance that none of these data is very accurate. At the end I shall give you a brief description of some of the political aspects of the problem.

### PRICES

Let us first look at the price situation. The break in prices of farm products began in July, 1920, and in non-agricultural products in November. In December 1920, the index of wholesale prices of agricultural products had fallen to 140, and of non-agricultural products, only to 208. The index of non-agricultural products in its lowest year in 1921 never got closer than 34 points to the 133 for agricultural products in that year. Since 1921, however, it has declined, except for a slight rise at first to 1923, whereas the index for agricultural products has risen steadily, so that it was within six points of the other in 1927, and is now above it.

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†Professor of Agricultural Economics.

A much safer comparison, however, is in terms of prices at the farm, and that is by no means as favorable to agriculture. The index for this series fell to 116 in 1921 and stood at 131 in 1927. It has risen to 148 in May, 22 points above May of a year ago, higher than in any month since 1920 except August, 1925. What is now officially announced each month as the index of "purchasing power of farm products" is the ratio of prices at the farm to wholesale prices of farm products. This had risen to only 91 in January, 1928, the last month for which it is available (because of a shift in the base periods in the Bureau of Labor index). The spread between the prices received by producers and paid by consumers of farm products, according to the Cornell index, now stands at 190, and has risen 10 points even since 1924. Transportation rates, urban rents and urban wages are the principal items in costs of distribution. Railway freight rates scarcely rose at all until after the war, and have taken only one cut since. The two most commonly used measures of urban wages stand at 229 and 250 for the latest year available (1926).

### Volume of Product and Income

The income of agriculture, however, reflects physical volume of goods produced and consumed as well as prices received and paid. The index of crop production in the three years 1924-26 was ten points above the 1910-14 average, and animal husbandry production thirty-eight points.* These two indexes of physical volume combined, multiplied by the index of prices at the farm, should give the index of the gross value of farm production, which according to the data compiled by the United States Department of Agriculture, stands for the years 1924-26 at 69 points above that for the years 1910-14. The indexes of farm prices for these years average 139. This leaves 122 as the index for physical volume, which may be taken as a rough average of the 110 and 138 for crops and livestock respectively. For the whole period from 1910 to 1927, this would make an increase of 28 per cent in the physical volume of production, which is taken into account along with the relatively unfavorable price situation when an index of gross value of product is used.

The next question is, what will this larger gross income buy in goods and service used by the farm and family? The answer is obtained by dividing the index of gross value of product by an index of prices paid by farmers, which stood at 172 in 1926, the last year for which it is available. This shows the farmers of the United States to be at least as well supplied with purchasing power as in 1910-14, the index being 103. This series also brings out the circumstance generally appreciated that it was in the years 1917 and 1918 when retail prices, farm wages and taxes had not kept pace with prices received by farmers, that the farm people of the United States prospered most.

Furthermore, we must know not only what prices were paid for farm machinery, feed and other supplies, but how much was bought; and the same for hired labor, taxes, and family supplies. Such data as there are indicate

*Harvard Economic Society indexes. A small factor in this increase in animal husbandry sales is the reduction in the size of herds of beef cattle that occurred from 1922 onward. The major factor in it appears to be a larger output of livestock products per animal unit and a shorter fattening period for meat animals.

that the quantity of goods and services bought increased 28 per cent between 1910 and 1920, then fell off slightly to 1922, and is now 45 per cent above that of 1910. The quantity of goods and services purchased for family living has no doubt increased fully as much. A much larger percentage of the farmers have automobiles, electric or other lighting systems, heating and water systems, victrolas or radios now than before the war.

The mortgage indebtedness of the owner-operated farms of the United States was $1,726,000 in 1910, $4,004,000,000 in 1920, and $4,517,000,000 in 1925. Short-time borrowing has surely increased in equal proportion. The average interest bill of the farmers has increased more than their income.

Taxes on farm real estate are two and a half times their pre-war level, and show no signs of decreasing. An unusually large volume of public construction at high prices in 1918-20, financed by bond issues, is one factor in this. But continuing higher wages and salaries and higher prices of construction materials are probably larger factors.

Wages of hired farm labor partly reflect farm prosperity and partly industrial competition. Looked at as farm expenses, they have about kept pace with gross farm income.

It would thus appear that although the purchasing power of farm incomes is now fully as high as before the war, it is by no means so nearly adequate to the demands upon it. Part of these demands are for the additional livestock, and feed, and machinery, and fertilizer, that are necessary for the increased volume of production that has offset the low relative prices. Others are for automobiles and other conveniences and comforts which are surely necessary unless the plane of farm living is to fall much behind that of urban living.

In consequence of the foregoing, large numbers of farm families in the United States have not met all their expenses even during the past three years. Those without mortgage indebtedness and with no unusual expenses, such as for maintaining children away from home at school, have usually been able to make ends meet; no doubt likewise another large group is made up of those who have been willing to keep their plane of living down to a pre-war basis. Others have done it only by working harder, and working members of their families harder and hiring less labor. Upkeep of buildings and fences has been neglected on many more farms than is usual.

Some positive evidence of the foregoing condition appears in the increase in mortgage indebtedness between 1920 and 1925 previously mentioned, in the continuing rate of farm foreclosure and bankruptcy, and in the decrease in number of students attending agricultural colleges. It is to be remembered that this increase in mortgage indebtedness has occurred while price levels have been declining and in particular while prices of farm land have been falling rapidly. A large part of this increase in mortgage indebtedness resulted from converting short-term notes contracted in 1919-22 into real estate mortgages, but some of it represented continuing losses in 1923 and 1924. No data are available as to changes in mortgage indebtedness since January 1st, 1925. The farm bankruptcy rate jumped from 0.21 per 1000 farms in 1920-21 to 0.50 in 1921-22, 0.93 in 1922-23, and to slightly over 1.20 per 1000 for 1924, 1925 and 1926. Only in 1927 does the rate show a decline to

0.99 per 1000 farms.* Of the farms in the United States reported as changing ownership in 1926, excluding the 10.3 per cent that were involved in the settlement of estates, 37.8 per cent were forced sales (foreclosures, bankruptcies, delinquent taxes). The comparable figure for 1926 was 35.5 per cent.†

### Comparison with Urban Industry

In order to understand the state of mind of the agricultural population at present, one must do more than make comparison with pre-war agriculture. Of more importance is comparison with changes in the prosperity of other economic classes. Urban wages are higher in money terms than in 1920, and the cost of living is lower. Thus labor has gained while agriculture has lost. "Real incomes" of New York State factory workers appear to be a fourth higher than before the war. If wages of farm labor are looked at as the income of one large part of the rural population, they have changed partly along with city workers' incomes and partly with farm incomes. They reflect on the one hand the ability of the farmers to pay wages and on the other hand the competition of urban employments.

Comparison is also commonly being made of the returns upon funds invested in agriculture and in city enterprises. A considerable part of the returns in agricultural investment takes the form of family living—use of dwelling, use of automobile, fuel, dairy and poultry products, meat, fruit, vegetables, etc.—obtained from the farm. In the usual calculations, these are given rough valuations on the basis of what they, or some rough equivalent of them, could be sold for at the farm, and these valuations are combined with the net money incomes of agriculture to compute a return on the investment. If one reckons on this basis, the farms of the United States in the crop year 1926-27 yielded a return for the funds invested and the labor and management of the farm proprietor equal to about 4 per cent on the estimated value of the land, buildings, livestock, machinery, and current operating balances, plus $700 to each proprietor for his hired labor and management. The average return per employee in city industries computed by the National Bureau of Economic Research was $628 in 1918 and is somewhat higher than this now.‡ But obviously a $700 income on the farm computed as above is not on a comparable basis with a $700 city income. It is usually suggested that for purposes of a comparison of this kind, the least objectionable procedure is to convert both incomes to the same basis of valuation, either at the farm or in the city. If the family living obtained from the farm was purchased at city prices, it would cost at least twice the valuation at the farm used in the above figures. On this basis an allowance of $1000 per farm for the labor and management of the farm proprietors would still leave a 5 per cent return on the capital invested. The comparable figure for the year 1925-26, a better year for agriculture, would be 6.3 per cent, and for the year 1920-21, the low point, 1.5 per cent. It is not to be inferred that these latter percentages represent a true comparison of farm and industrial returns on funds invested and management. But they undoubted-

*Yearbook U. S. Department of Agriculture.
†Circular 15, U. S. Department of Agriculture.
‡Crops and Markets, July, 1927.

ly more nearly approach a true comparison than when farm and industrial returns are reckoned on different bases.

In interpreting these figures, one should also realize that these are average farm returns, in which all the farm operators in the United States are counted equally, including the large proportion of small cotton farmers living in the southern states, of whom a large proportion are croppers and tenants.* Part of the apparent low incomes of farmers in the United States is a simple matter of geography, as is made clear by the fact that 52 per cent of the farm population of the United States live in the 14 Southern States, where all incomes are low, whereas 80 per cent of the non-farming population live in the remaining 32 states where all incomes are relatively much higher.†

## Land Values

The foregoing returns for the years 1925-26 and 1926-27 are calculated on the basis of valuations of farm property readjusted for changing values each year. Land values in the United States are 50 points lower on the index scale now than in 1920, and only 19 points above those of 1912-14. If 1920 valuations were used in computing present returns, deducting $700 for each farm proprietor in 1926-27 would leave only 2.8 per cent as return on the investment.

This decline in land values is the most outstanding development of the period under review. Land values are already far below the general price level, and they are even further below the present level of farm incomes. The experience is a new one for American agriculture, and highly significant. Land values declined in the North Atlantic States from 1880 to 1910 because of the cheapening of farm products following the opening of the western prairies; but the present decline has reached all sections of the country. The central Corn Belt States and the Cotton States have experienced the largest decline.

It is easy to see why land values should have declined somewhat in 1921 to 1923. A "boom" struck the land market in many sections in 1918 to 1920. This boom was unconsciously based on the assumption that the high price level had come to stay. In Iowa and Georgia, land prices rose almost as far as the wholesale price level before the break came. With the rapid decline in prices of commodities in 1920-21, one would expect that the part of the new high level of land prices which was based on high commodity prices would disappear rather quickly. But land prices are still declining, and the trend of prices of farm products, or at least of farm incomes, has been upward for some time, although not very noticeably since 1924. What is the explanation? Some of the decline since 1921 is no doubt merely a matter of lag in readjustments. This might account for a continuation of the decline, but it will not explain the low level which has been reached. This is largely explained by a shrinkage in that part of current land values which represents capitalization of anticipated increase in land income. Cash rental rates on farm land in Iowa rose at the rate of about 20 cents per

*A cropper is a person who contributes only his labor and receives his wages as a share of the crop. The cropper system is prevalent in the cotton growing states, especially among the negro farmers.

†Data from "Income in the Various States" by the National Bureau of Economic Research.

acre per year between 1900 and 1919, and 34 cents per acre between 1910 and 1919.*

Comparable figures for Ohio are 8 cents and 10 cents; for Southern Wisconsin, 10 cents and 15 cents. Under these circumstances, land was selling even before 1919 and 1920 on the assumption of large anticipated increases in net income. As high as sixty per cent in some areas of the current value of land in 1919 and 1920, according to Chambers' analysis, represented this element.* Although cash rental rates have been rising again since 1923, landowners no longer see the future in such rosy colors. If they were unconsciously assuming a rate of increase in net income of 15 cents per acre in 1920, and are assuming a rate of only 5 cents now, there is ample explanation in this for a level of land values considerably under the general price level.†

Further explanation is found in the fact that forced sales have been so numerous in many neighborhoods as to have established the general level of land prices there, and forced sales are frequently at bargain prices.

The demand for farms is poor in large part because young men are not in the market for them as they were before 1920. The decline in land prices has made them afraid to buy farms. Furthermore, they have not been accumulating purchasing power at the usual rate, partly because of low incomes as tenants, partly because living expenses have risen since the introduction of the automobile and other modern conveniences.

It is now nearly three years since associations of farm real estate dealers began to say that farm land values had turned upward. But the latest official information from the U. S. Department of Agriculture indicates that the movement is still downward in most sections. With net incomes and cash rents slowly working to higher levels, it seems probable that a turn upward will come soon, probably within the next five years, unless the wholesale price level falls more rapidly than is commonly expected.

## Rural Wealth

The severe decline in land values has reduced rural wealth very markedly. The farmer who purchased a farm in 1920 at $20,000 under a mortgage of $10,000, assuming that he has made no payments on his mortgage, now has a farm worth, as an average figure for the whole country, $14,300. His equity has shrunk from $10,000 to $4,300. A very large proportion of those who purchased under the conditions assumed no longer have their farms. They were unable to meet their heavy interest and tax payments in the lean years from 1921 to 1923. If this same farmer had made his purchase in 1913, his farm would probably have cost him $12,000 and his mortgage would have been $6,000. Assuming no payments on his mortgage, his equity would have risen from $6,000 to $8,300. But $8,300 in 1928

*C. R. Chambers, "Relation of Land Income to Land Value", U. S. Department of Agriculture, Department Bulletin No. 1224. See pages 19 and 30.

†This is made clear by inserting these rates and other assumed amounts in the formula for valuation of a permanent income bearer with incomes increasing at a constant rate, in which v=value per acre, a=current net income, r=prevailing rate of return on safe investments, and c=anticipated increase in annual net income.

$$v = \frac{a}{r} + \frac{c}{r^2}; \qquad 160 = \frac{5.00}{.05} + \frac{.15}{.0025}; \qquad 120 = \frac{5.00}{.05} + \frac{.05}{.0025}$$

represents 5 per cent less purchasing power in the wholesale market than $6,000 in 1913.

The complete picture of the decline in rural wealth must include farmers in both the situations just described and many more, with all sorts of mortgages and at prices all the way from those of 1850 to those of 1928. It must take account of the payments constantly made on mortgages, especially the heavy payments made from 1916 to 1920. On the other hand, it must reckon with the fact that whenever farmers retire to the city, or estates are settled, wealth is drained off to the city and replaced by new mortgage indebtedness. If the agricultural census of 1925 be taken as a cross-section for comparison with the 1910 census as another cross-section, the average equity of mortgaged owners on their farms in 1910 was $4,574; in 1925, $5,560. But in terms of the wholesale price level of these two years, the 1925 equity was only four-fifths as great as that of 1910. In addition, 36.1 per cent of the owner-operated farms were mortgaged in 1925 as compared with only 33.6 per cent in 1910.

## Population Changes

The Census Bureau's best estimate of the farm population in 1910 is 32,077,000. The nearest comparable figure for 1920 was 31,614,000;* for 1925, 29,638,000.† The estimate of the U. S. Department of Agriculture for 1927, based on a rather meagre sampling of population movements, is 27,892,000. The decline estimated for 1927 is 604,000.‡

The popular explanation of this is that it represents a response to the relatively unfavorable position of agriculture. Apparently this is a minor element in it. A more important explanation is the mechanization of agriculture which has taken a new spurt since 1915 with the wide adoption of the automobile, the tractor, and the combine harvester for small grains. But the most important explanation of all is the slackening of agricultural expansion into new areas. The rural population has been declining in the older farming regions for a long time—over a hundred years in many sections of the East; for perhaps thirty years in Iowa and the prosperous farming sections of the North Central States. But the new rural population on the western frontier and following the logging-off of timbered lands, until some time after 1910 was enough to more than offset the losses in the older farming regions.

In spite of the loss of rural population, and the mechanization of production, there does not seem to have been much of a reduction in the amount of labor per farm. The number of persons "gainfully employed" in agriculture in 1910 was 11,400,000; in 1920, 11,300,000; and in 1925, 10,700,000.§ The corresponding numbers of farms for these three census periods were 6,362,000, 6,448,000, and 6,372,000. Reduced to a per farm basis, the data on gainfully employed became 1.79, 1.75 and 1.68 respectively.

*Fourteenth Census, Agriculture, p. 891-2.

†United States Census of Agriculture, 1925, Summary of Statistics by States, p. III, p. 52. Also *Press Summary*, published by the Census Bureau, May 4, 1927.

‡Crops and Markets, April, 1928, p. 139. Published by the U. S. Dept. Agr.

§These figures represent adjustments from those published by the Census Bureau, which are not on a comparable basis at different census periods. See the American Economic Review Supplement, March, 1928, p. 124.

It must be remembered that production per farm has increased nearly thirty per cent since 1910. Not all of this increase has been of the kind that can be handled by power and machinery.

The data prepared by Dr. E. Dana Durand of the Department of Commerce indicate that output per worker in agriculture increased 47 per cent between 1900 and 1925, exactly the same as in manufacturing. Between 1910 and 1920, agriculture gained 20 per cent in output per worker, and between 1920 and 1925, 18 per cent.* These figures mean roughly that 10 persons in 1925 were turning out the same agricultural product as 14 in 1910 and 12 in 1920.

The decline in rural population has significance in another way. It means that the income of agriculture is distributed over fewer persons, giving a larger *per capita* rural income in consequence. If the index of gross value of product of 172 for 1926 is adjusted for the decline of 11 per cent in rural population between 1910 and 1926, it is raised to 193; and the corresponding income buying power index of 103 is raised to 115. There are, however, a number of uncertainties in the data which make such an adjustment of questionable authenticity. If the adjustment is made on the basis of gainfully employed rather than total rural population, the 193 is lowered to 183, and the 115 to 109.

## Regional Differences

Needless to state, no description of agricultural conditions in a region so varied as the United States can be very satisfactory. But space forbids more than a brief mention of sectional differences. The foregoing discussion is in terms of the United States as a whole. There are wide differences among districts. In the spring wheat section, the agricultural depression was partly due to low prices for wheat and partly to a succession of poor harvests. The depression came soon enough to check the land boom in this section. Since then, the crops of 1924 and 1927 have improved conditions much, but the balance sheet is still unfavorable. Bank failures and farm foreclosures have been heaviest in this region.

The corn belt was especially affected by the land boom, and by an overexpansion of corn and hog production during and just following the war. Cattle feeding was financially disastrous for two winters in succession. Hog prices are now only a few points above the 1910-14 level, since hog production is at the peak of the cycle. The Iowa price index is therefore considerably lower now than in 1927.

The range country suffered severely from the decline in beef-cattle prices in 1921. Production had expanded under the war stimulus into areas that could not sustain it under more normal prices, to say nothing of those prevailing in 1921 and 1923. Conditions have gradually improved, partly as the result of better wool and lamb prices, and partly with the decline in marketings of beef cattle. Today, with beef-cattle prices 68 per cent above 1910-14, the range region is relatively in the best condition of any farming section.

The cotton region experienced extremely low prices in 1921, and then very high prices in 1923 and 1924 because of the boll-weevil ravages. These

*See American Economic Review Supplement, March, 1928, p. 122-130.

prices stimulated rapid expansion of cotton growing on the western frontier, and resulted in an 18-million-bale crop in 1926. Prices fell to 11 cents a pound. The 13-million-bale crop of the past year is selling around 19 cents a pound, or for a total value 250 million dollars more than the preceding crop. In the older cotton states, many sections are in financial straits. The boll-weevil has produced its effect along with the price movements. The land boom was as pronounced in the South as in the corn belt, and the recession has been equally severe.

Land prices in the East rose little during the boom and have declined little since. The prices of the principal farm products of this section have been far more stable than those of cotton, wheat and corn. Higher freights from the West have strengthened eastern markets relatively. Consequently the East has only partly felt the agricultural depression.

## Political Aspects

The thought that comes to one most forcibly after reviewing the efforts at farm relief is the belatedness of some of them. The Association of Land Grant Colleges should have set a committee at work in 1921 in place of in 1927. The same is true for the United States Chamber of Commerce. The fact is that these people expected agriculture to recover much sooner than it has. They did not appreciate the enormity of the catastrophe. After prices improved in 1924 they tended to think too much in terms of current operating statements and not enough in terms of balance sheets. It always takes time for busy people to readjust their thinking even after they make up their minds they need to do it. It was not until the farmers developed radical leaders who began to demand extreme measures, that their plight was taken seriously by the general public. The extremists of 1921 and 1922 who talked of bare-faced price-fixing were largely ignored. Nobody expected their plans to receive much attention. But when the first McNary-Haugen bill came within 40 of half the votes cast in the House in June, 1924, there followed some startled thinking. It took even more than this, however, to swing the Chamber of Commerce and agricultural college deans into action in 1926 and 1927. They had to be convinced by persistent pressure that the exponents of this new system were in deadly earnest.

It is a fair description of much of the activity since 1924 to say that it has been principally aimed at heading off radical measures.

There was a pronounced spasm of farm relief activity at the very start. The depression fell with heavy hands upon the closing days of the Wilson administration. In the short final session of the 66th Congress, two bills were introduced to relieve agriculture, one the Fordney emergency tariff act, vetoed by the President on March 3, and the other reviving the War Finance Corporation and directing it to assist in the financing of the exportation of agricultural products. This latter bill was passed over the President's veto on January 4. In April, the wholesale index for farm products reached 117. The new Congress put the "Commission of Agricultural Inquiry" at work on April 25, passed the emergency tariff act in June, and three more relief acts in August. When these had been passed, as well as the new tariff act in September, 1922, and the new Intermediate Credit act the fol-

lowing August, Congress had played its full bag of tricks. But the farmers were still unsatisfied. Foreclosures were still on the increase and likewise bank failures. Land prices were sinking fast. Since then, the course of farm relief has been determined largely by the agricultural interests themselves, represented in Congress by a largely non-partisan agricultural bloc. It was this bloc, already rather closely knit, that the ill-fated President's Agricultural Conference encountered to its great discomfiture in the winter of 1924-25.

It is not possible to understand events up to this point, and certainly not those which followed, without some knowledge of another important contributing element. Secretary Hoover undertook his task of building up the Department of Commerce with a splendid vision of a central organization in Washington that would coördinate all the commercial activities of the government. But he found the important foreign phases of it handled by the commercial attachés of the Department of State, and the domestic phases of it, so far as agricultural products were concerned, in the hands of the Department of Agriculture. A large proportion of the export trade of the United States was in farm products. The including of a $250,000 appropriation in the deficiency bill of May, 1921, enabled him to make a start in the desired direction. This was to be used on "export industries." An appropriation was asked in January, 1922, for expansion of the work with "foreign industries." The phrase "and related problems in agriculture" inserted by amendment into the $500,000 appropriation to study the rubber situation was made the basis for a broad program of research in the field of domestic agricultural products. In January, 1924, the Jones-Winslow bill was introduced, designed to put the foreign service of the Department of Commerce on a salary basis commensurate with that of the attachés in the Department of State. In October, 1921, Secretary Hoover in a letter to Walter F. Brown, chairman of the reorganization committee, had indicated his view that the work of the Department of Agriculture should in general end when the crop left the farm, that "the Department of Agriculture should tell the farmer what he can best produce, based on climatic, soil and other cultural conditions, and the Department of Commerce should tell him best how he can dispose of it." Dr. Klein, appearing in behalf of the Winslow bill, stated that "economic and commercial" investigation should be under the authority of the Department of Commerce. The Jones-Winslow bill, as introduced, definitely limited the Department of Agriculture to collection of crop and live stock statistics, demonstration of standards, and purely scientific investigations.

Secretary Wallace, in turn, came to Washington with a splendid vision of converting the Department of Agriculture into an agency that would take heed of economic as well as cultural factors, so that in the future farm leaders would not be able to point the finger of derision at it and accuse it of only helping the farmers to overproduce. He straightway set about bringing all the economic work of the Department into one Bureau and strengthening it. Congress in March, 1921, appropriated $50,000 to the Department of Agriculture to collect and disseminate information on production and consumption of farm products in foreign countries.

In the conflict that developed between these departments, Secretary Hoover had the great advantage of the support of the President after Harding's death. President Coolidge at once made Secretary Hoover his adviser on agricultural matters in place of the Secretary of Agriculture. But Secretary Wallace had the advantage of the support of the agricultural bloc.

The Ketcham bill was introduced in 1924 to meet the Winslow bill, passed the House, and was held up in the Senate on June 5 by an objection from Senator King. The Winslow bill failed of the necessary votes in the House on the same day. It was attacked vigorously by Congressman Dickinson, of Iowa, leader of the agricultural bloc in the House, on the ground that it represented an attempt of the commercial interests to get control of agriculture.

When the Capper-Haugen coöperative marketing bill, embodying the ideas of President Coolidge's Agricultural Conference on this subject, was introduced in February, 1925, it was attacked and defeated by the agricultural bloc, on the ground that it took coöperative marketing out of the Department of Agriculture where it belonged and put it where the Department of Commerce could get hold of it, and in addition, set up rather rigorous governmental machinery for its control. The coöperatives back in 1925 were carrying their syndicalism almost to the point of complete non-intervention. Friendly assistance, such as they were getting from the Department of Agriculture, they welcomed; but not the kind of supervision that certain mercantilistically minded members of the Agricultural Conference deemed highly necessary for them. It is interesting to observe how the syndicalistic philosophy of the coöperatives later gave way before the allurements of McNary-Haugenism.

It will be remembered that the agricultural bloc not only defeated the Capper-Haugen bill in the closing days of the first Coolidge administration, but also the first Mellon tax bill and other administrative measures. It figured conspicuously later in the failure of the Senate to confirm the nomination of Warren to the Cabinet. The fight for the McNary-Haugen bill had already given a new cohesiveness to the agricultural bloc. It is, therefore, not difficult to understand that the temperature was running very high in certain administrative circles in the winter of 1925. The necessary condition imposed upon all prospective incumbents of the secretaryship of agriculture was that they agree to rid the department of all who had been in any way connected with the McNary-Haugen movement and the defeat of the administration program.

The movement to keep agriculture from domination by the business interests had therefore taken on two related phases: one to establish a system that would equalize economic conditions in the city and country, and the other to protect the Department of Agriculture against the encroachment of the administration. Secretary Hoover's opposition to the McNary-Haugen plan had the effect of identifying these two interests. The McNary-Haugen scheme left the Department of Commerce entirely out of the picture.

The conference called by President Coolidge in the winter of 1924-25 was apparently his response to a request from farmers' organizations made before Secretary Wallace's death in August, 1924, that he have Secretary

Wallace call such a conference. McNary-Haugenism was in the air. Secretary Wallace had been one of the first converts to it. The President chose the personnel of his conference and organized it with great care. It performed according to his expectations, but as already pointed out, to little avail. Its most solid achievement was preparing the way for the passage of the Purnell act securing additional support to the state experiment stations. Three of its members were agricultural college deans. It was instructed to report on three subjects: (1) the emergency in the cattle industry, (2) the administration of government departments as they touch agriculture and (3) pending legislation. It despaired of its task before really getting into the third of these subjects. What little it did say strongly suggested the Republican doctrine of protective tariffs for agriculture, self-sufficiency, and reduced exports of farm products. It was a Republican Conference. No doubt its recommendations on the cattle situation were sound and well considered.

The report of the National Industrial Conference Board was noteworthy as an effort, and no doubt a fairly successful one, to convey the idea to the business interests of the country that agriculture was in a bad way. Its treatment of agriculture was sympathetic. Even if its data and analysis were startling in places, these did not damage its usefulness for the purpose named. The report contained no recommendations. These were left for the later report of the "Business Men's Commission." This body of men faced the so-called surplus problem squarely and honestly, accepted as valid the position of the McNary-Haugenites that either an economical equivalent for industrial protection must be found or protection for industry must be revised. It was the second of these alternatives which they chose. The other recommendations are upon an equally high plane.

The rest of the progress of farm relief relates to the McNary-Haugen proposal and the efforts of the second Coolidge administration to stem the tide against it. At the start, the administration clearly had the advantage in the conflict. The overwhelming vote by which the administration was returned to power in 1925, and the heavy preponderance of administration support in the House, seemed to many to presage the doom of McNary-Haugenism for all time. But such has not been the case.

The agitation for legislative measures to improve the fortunes of agriculture reached its climax in May, 1928, when the McNary-Haugen bill passed the Senate with a vote of 53 to 23, and the House with a vote of 204 to 121. The "farm bloc" for various reasons was unable to pass it over the President's veto of May 23. Even in the Senate several members switched their votes so that the final vote was 50 for passing to 31 against. The 1928 veto message is a briefer and more emphatic statement of the same objectives that were raised in the 1927 message. Those objectives in it which relate to its administrative features, the great extension which it will require of governmental participation in private affairs, are on entirely valid grounds. Those which relate to its price-influencing intent and its use of the taxing power to benefit one part of the population at the expense of another, are equally valid objections to the protective-tariff system of the United States, and that a Republican president of the United

States could seriously advance them is further evidence of the naivété, or the guilelessness, of the Republican leaders on the whole subject of the protective tariff. The present McNary-Haugen bill, although still providing in effect for selling the exportable surplus on the foreign market at less than domestic prices, makes this only a measure of second resort, is much more clearly an effort to assist in "orderly marketing", and recognizes more clearly than its earlier prototypes the basic need of "orderly production" as distinguished from orderly marketing.

It is difficult to forecast the part which the McNary-Haugen propaganda will play in the coming election or in public affairs in the United States in the next few years. The agricultural interests have become much more closely united as a result of the struggle to pass the McNary-Haugen bill. It has proved to be very effective as a measure around which to rally the agricultural interests. The farmers of the United States realize more clearly than ever before that the ruling political faction in the United States is strongly identified with the business interests. Their political representatives in Congress are likely to act on this assumption in the next few years whichever party wins, but especially if a faction is returned to power which continues the present administrative policy. The agricultural bloc will be strong enough to obstruct undesired legislation, and possibly even pass desired legislation over a president's veto, merely by aligning itself upon occasion with the opposing party.

# A STUDY OF VARIATIONS OF MARQUIS WHEAT IN RELATION TO DIFFERENT SPACING OF PLANTS.*†

GEORGE EARL DELONG‡
*Dominion Experimental Station, Lacombe, Alta.*

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## INTRODUCTION

Variation in variety type is causing considerable discussion among agriculturists who are interested in the production of registered seed grain. Variation in the type of Marquis wheat has been the focus around which much of this discussion has centred. These discussions have given rise to numerous speculations concerning the amount of variation which is directly attributable to environment and maturity, and that which may be due to recombinations of parental characters resulting from natural crossing between the parent variety and other sorts which had their origin as mechanical mixtures or as sports of the parental variety. Agronomists agree that most populations of our cereal crops are made up of several biotypes which fluctuate in varying degree from the accepted variety type; they do not agree, however, on the line of demarcation between fluctuation of variety type due to environment and aberrant biotypes which are the result of recombinations of parental characters.

## THE PROBLEM

Saunders (*12*), Newman (*9*) and Clark, Martin and Ball (*2*) have described Marquis wheat. The descriptions given, however, apply to the average of the field crop but do not include the range of fluctuation within the type which may occur as a result of different environmental conditions and different degrees of maturity. Percival (*10*) states, "In no cultivated crop do we know how much of that which we see should be attributed to the response of the plant to the environment and how much to constitution". This difficulty stated by Percival is, in a word, the problem confronting the man interested in the production of registered seed of Marquis wheat.

In an endeavor to improve the seed stocks of Marquis wheat at the Dominion Experimental Station, Lacombe, Alberta, the practice has been to preserve the different selections as pure lines for at least two generations. The $L_1$§ generation consists of a head row four feet long and the $L_2$§ generation consists of an increase plot of one row 66 feet long. These $L_2$ rows have always been spaced one foot apart and seeded on land which has been thoroughly summer-fallowed the previous season. It has been found

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†This investigation was conducted at the Dominion Experimental Station, Lacombe, at the suggestion of Mr. G. M. Stewart, District Inspector, Dominion Seed Branch, Calgary, and with the approval of Mr. F. H. Reed, Superintendent of the Station. The author is indebted to Professor J. R. Fryer, University of Alberta, for valuable suggestions and criticisms in the preparation of this report. Valuable criticisms were also given by Mr. L. H. Newman, Dominion Cerealist, Central Experimental Farm, Ottawa, of those portions of the investigation which refer to variety type.

‡Assistant Superintendent.

§$L_1$ refers to the first generation of the progeny of an original head selection from an apparently pure stock; $L_2$, $L_3$, etc., refer respectively to subsequent generations.

that this method of increasing selections created a problem in that plants produced under such extreme environmental conditions differed morphologically from the originally selected parent plants which were grown under average field conditions.

The production of these morphological variations, which in this case are undoubtedly due to extreme environmental conditions, forces one to realize that environmental conditions may be responsible for wide deviations from the accepted Marquis type. This realization accentuated in general the difficulty of distinguishing between variations due to environment and those which may be due to differences in genetical constitution.

During the last few years field inspectors for the Canadian Seed Growers' Association have experienced difficulties of this sort. They have found numerous aberrant types in fields of Marquis, some plants with bearded heads, some similar to certain other known varieties as well as other plants unlike any recognized sorts. They have also found what is much more confusing, viz., plants diverging in varying degrees from the accepted Marquis type.

The object of this investigation has been to secure evidence that might assist in differentiating between maximum deviations from the standard variety type directly attributable to environmental influences and deviations arising from recombinations of genetical factors.

## Review of Previous and Related Work

Percival (*11*), in discussing methods and value of selection states, "My conception of old established agricultural and horticultural varieties of our crop plants is that, apart from accidental mixture or outcrossing with different varieties, the several distinct lines usually discovered in them originate from mutation and subsequent crossing of the mutants with the parent type and with each other. True mutations, which I consider are in all cases responses of the plant to the environment, appear to be of great rarity, but only a few are needed to give rise to a large number of new forms by resorting and recombination of their factors and those of the parental form after crossing. The time taken for a recently isolated line to become an obviously mixed population of distinct lines will depend upon the frequency of mutation, and the facility for hybridization."

Percival appears to stress the importance of mutation and subsequent intercrossing as the source of aberrant forms. In the case of Marquis wheat, however, Newman (*9*) considers that most of the aberrant types found in Marquis consist very largely of mechanical mixtures. It would appear that, due to the prevalence of mechanical mixtures of other varieties, intercrossing is more probable between Marquis and these mechanical mixtures than between Marquis and mutant types.

Engledow and Wadham (*6*), in their yield studies found that, "In comparing pure lines on the single plant basis it is essential to confine observation to the "modal" tiller-number sub-population of each line. In no case can close comparison be of value if made in terms of general populations". This statement may apply to yield comparisons but lacks significance in the identification of varieties as it is the plant falling between the "modal" form

and either "extreme" which is most difficult to classify and which creates the problem.

These investigators recognize fluctuation among cereal plants and the difficulty involved is expressed in their statement that, "Investigations upon metrical characters of cereal plants have always presented great difficulty on account of the range of fluctuation which is always encountered." They found that "A field crop is a population of single plants enjoying different environments." They also found that, "Of the total sown, only a quarter to a seventh grow into mature plants. The losses are irregularly distributed so that many different spatial arrangements pertain in the field."

Later work by Engledow (*3*) revealed the fact that there was great irregularity in the rate of deposition of seeds by the seed drill. It was shown that, "The number of seeds deposited by the drill on any one-foot length of row is practically independent of the number on the preceding or next following foot", and that " 'misses' and large 'gaps', as well as the distribution of seeds by drills, affects the development of the plants."

Engledow and Wadham (*6*) found a crop so variable that in an endeavor to lessen "fluctuation" in plants studied, suggested certain precautions of which the chief are:

> "Selection of seed, sowing on one day and by uniform dibbling, and the exclusion of plants which do not germinate in the 'modal' period (of two days) for the whole population.
>
> "A similar exclusion of the plants of end rows, of the end plants of all rows, and of plants one or both of whose neighbors in the row fail to survive till harvest.
>
> "At later stages and for special purposes observation was limited to plants which flowered on the 'modal' day and which produced the 'modal' number of ears."

They endeavored to eliminate "fluctuation" by using one tiller (the best developed) from each plant and suggest restricting experimental populations to plants all of which produce the same number of tillers.

Harrington (*7*) found considerable variation in type as among different strains of so-called Marquis wheat and also found considerable fluctuation as among individual plants within any strain of Marquis wheat. Of fifteen strains studied "Nine strains proved to be typical Marquis and six non-typical."

The variability of strains is shown by the following quotation from Harrington (*7*); "In taking data on the progeny plants the spikes that were most like the parental spike in size were chosen for measurement. This was done because it was observed that relatively large difference in spike density and in glume characters existed among the fully mature spikes of a single plant. The largest spike of each plant proved less accurate for use in comparing one plant with another than a well developed spike of approximately the average size for the strain. To insure accuracy in the comparisons progeny spikes differing from the parent spike by more than 10 per cent in length were not used excepting in a few cases where spikes of the average size were not available."

Kiesselbach and Sprague (*8*), in studying the relation of the development of the wheat spike to environmental factors, found that "the number of plants per unit area averaged 92 per cent as great on poor locations as on good ones, and since the difference favored the individual plant development on the poor locations, it would tend to make them more nearly alike rather than to accentuate the plant differences. Tillering was reduced from 3.3 to 2.0 spikes per plant by poor locations and the total number of spikes per unit area was reduced 45 per cent. The number of grains per spike was 24 per cent less on poor locations and since average kernel weight was practically the same (4 per cent higher on the poor soil), the reduction in yield from 32.2 bushels to 14.4 bushels was due primarily to fewer spikes with fewer grains. The loss in number of grains per spike is due to the 12 per cent reduction in number of fertile spikelets and the 14 per cent decrease in grains per fertile spikelet. Spike length reduced from 2.4 inches on good locations to 2.1 inches as poor locations. With reduced spike length there was a corresponding reduction of 12 per cent in number of spikelets per spike." They found that "Environmental conditions which reduce vegetative growth generally cause a reduction in tillering, culm length, spike length, number of fertile and total spikelets per spike, grains per spike, grain and straw yields, average kernel and culm weights, grains per fertile spikelet, and percentage of fertile spikelets."

The foregoing review indicates the great variability which different investigators have observed in cereal plants. Had these investigators been endeavoring to study variability instead of trying to eliminate it from their studies, in all probability a greater bulk of information concerning variability would now be available.

## Methods of Conducting Research

The Dominion Experimental Station, at Lacombe, Alberta, was asked by Mr. G. M. Stewart, District Inspector, Dominion Seed Branch, Calgary, Alberta, to coöperate in a study of variations in Marquis wheat which might result from planting under different spacing conditions. Mr. Stewart suggested a seeding plan and offered to supply the purest strain of Marquis 10 B available. (Marquis 10 B was found to be one of the purest strains by Harrington (*7*) and Newman (*9*)). The conducting and completion of the study came under the writer's immediate supervision. The data collected in this study appeared so interesting that, in view of the absence of similar data, it seemed wise to put them on permanent record.

Original stock seed of Marquis 10 B wheat was sown in the normal seeding season on a dark loam soil which had been thoroughly summerfallowed the previous year. In Lot 1 plants were grown in drills seven inches apart at the rate of six pecks per acre. In Lot 2 the plants were grown in drills spaced eighteen inches apart with the plant distribution in the drill similar to Lot 1, and in Lot 3 the plants were spaced eighteen inches apart each way. It will be noted that these lots were again divided into (a) and (b); (a) refers to fully matured portions and (b) to immature portions of plants. Thus (2a) refers to mature portions of plants from drills spaced eighteen inches apart and (2b) to immature portions of plants from drills spaced eighteen inches apart. There was an abundance

of moisture available to the crop which made a strong, vigorous growth. Lot 1 was the only plot which appeared mature when the crop was harvested. The plants of all lots were pulled with roots intact on September 14.

One hundred counts or measurements for each character studied were made when collecting the raw data. While a larger number would have made the work more accurate, it was felt that the number used would indicate the possible trend of the variations. The use of one hundred counts or variates simplified the mathematical calculations. That they were sufficient in number to give fairly accurate results is indicated by the relatively low probable errors obtained.

In presenting this paper the writer has endeavored to draw a statistical* picture of the deviation from the mean variety type and thus to provide some information as to what variation one might attribute to environment. The graphic representations are given to assist the reader to understand and visualize the variation in the different characters studied. In these graphs the length of the cross-lined portion from the origin toward the right indicates the value of the minimum for the character in question; the length of the cross-lined section plus the heavy horizontally lined represents the mean value, while the total length represents the maximum value of the character.

## FINDINGS

### Numbers of Tillers per Plant

Engledow and Wadham (*6*) state that "a direct study of the nature and amount of 'plant to plant fluctuation' with graminaceous plants indicates that the most obvious and potent factor in this fluctuation is likely to be the phenomenon of tillering." They also state, "There is a seminal root system whose precise share in the activities of the whole plant has never been determined, and in addition, every tiller develops an adventitious root system of its own. Whether among the tillers there can occur a translocation and interchange of the products of root absorption and photosynthesis, it is impossible to say. Possibly a graminaceous plant should be regarded as a unit—not in the same sense that a plant of, e.g., *Helianthus annuus* is so regarded—but as a colony of individuals the younger at first dependent on the others but later, self established and competing with them." They conclude that "tillers are of different ages, physiologically as well as chronologically."

Percival (*10*) considers the cereal plant as a colony of individuals (tillers) rather than a unit. The main axis of the plant is supported by the seminal root while the tillers or laterals are largely supported by adventitious roots which develop during the formation of the tillers. The number of tillers per plant has but little significance in the differentiation of Marquis strains. On the other hand, this character responds quickly to environment and thus is of value in that it indicates to some extent the possible variation in plants due to environmental conditions. Although of little significance in itself, if linked up with other variable characters, it may help form a chain of evidence that will throw new light on the subject in

*"Principles and Methods of Statistics" by Chaddock (*1*) was used as a guide for the mathematical calculations.

question. In any case, it is a variable character and since we are studying variability it would be unwise to omit a study of what is possibly the most variable of plant characters.

It will be seen in Table 1 and Figure 1 that the number of tillers per plant showed a wide range of variation. Table 1 illustrates the distribution frequencies for the number of tillers in the different lots. It will be seen that the mean number of tillers per plant increases as the plants are allowed more room to develop. This is in agreement with the findings of Engledow and Skelton (*5*), who found that "within limits, the more vigorous the plant the more tillers it produces; and the facts displayed make it appear that greater vigor is evinced in 'all-round' form—not only more tillers but bigger ones (larger glumes and rachis)."

TABLE 1.—*Number of tillers per plant.*

| Mid-class Values | Lot 1 Normal seeding | Lot 2 18 inch Rows | Lot 3 Plants 18 in. x 18 in. |
|---|---|---|---|
| 2.5 | 100 | 73 | 3 |
| 7.5 | | 27 | 25 |
| 12.5 | | | 43 |
| 17.5 | | | 15 |
| 22.5 | | | 6 |
| 27.5 | | | 2 |
| 32.5 | | | 5 |
| Range | 1–5 | 2–12 | 3–33 |
| Mean | 2.5 | 3.85 ± 0.260 | 13.60 ± 0.917 |
| Standard Deviation | | 2.22 ± 0.106 | 6.50 ± 0.310 |
| Co-efficient of Variation | | 57.66 | 47.79 |

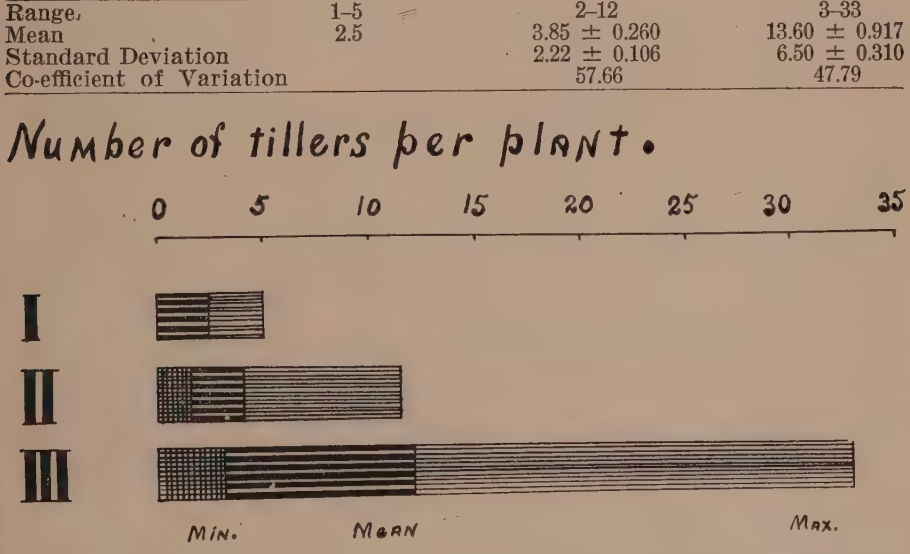


FIGURE 1. Number of tillers per plant. The wide range of variation, the minimum, mean and maximum number of tillers per plant are represented.

It is interesting to note in Table 1 and Figure 1 that while the mean number of tillers of Lot 3 is approximately four times that of Lot 2, the Standard Deviation of Lot 3 is only three times that of Lot 2 and the co-efficient of variation of Lot 3 is actually less than Lot 2.

The greater variation in the number of tillers per plant indicates the response of this character to spacing. The study of this character has not revealed any point of particular significance except that, since the plant shows such wide variations in number of tillers per plant when grown

under different spacing conditions, it would appear possible for it to vary in other characters as well.

### Length of Tillers

The length of tiller at first thought might appear to have no particular significance in a study of wheat variation. It is true that the normal fluctuation in the length of the tiller has little value in differentiating between Marquis and aberrant types; on the other hand, very tall tillers growing in fields of Marquis have always raised a question concerning their probable origin. The study of the length of tiller was made in an endeavor to obtain information on this problem.

Engledow and Wadham (*6*) state, "the main axis is usually bigger in all respects than the first side tiller which, in turn, is bigger than the second, *et seq.*" This observation holds true in most cases but exceptions are not infrequent in Alberta. An outstanding exception is the crop of 1924 wheat. A large proportion of this crop was seeded on a soil which contained practically no "moisture carry over" from the previous season. There was a subnormal amount of precipitation during April, May and June, with the result that the wheat made a sub-normal growth, developing but few tillers per plant, and these below normal in length. Heavy rains occurred during July. These rains falling on the warm fertile soils stimulated the wheat plants into a second tiller developing stage. These late tillers continued to develop and were in the bloom stage when the first tillers formed were fully mature. The late tillers were approximately one foot taller than the mature tillers on the plants from whence they sprung. They constituted fully 50 per cent of the crop as harvested and did not attain a greater maturity than the milk stage before fall frosts occurred. They proved a serious detriment to this crop as the threshed grain, because of the large percentage of immature kernels, graded "feed".

A further exception to the rule that each succeeding tiller is shorter than the one from whence it sprung has been observed when frosted seed is planted under conditions not ideal with respect to growth. As a rule a rather weak plant is developed, which produced a relatively small number of rather short tillers. If growth conditions improve during the growing season, a relatively large number of later maturing tillers may develop, a few of which are usually taller than the earliest maturing tillers of the same plant.

The length-of-tiller data given in Table 2 and illustrated in Figure 2 reveal some interesting findings. The standard deviation indicates that the variation in the length of tiller increased as the plant was allowed more room to develop. It will also be seen that there is a much greater variation in the length of the immature tillers than there was in the fully mature tillers of the same group.

The range of the variation in the length of tiller is of particular interest in that the upper extremes of the range frequently create a problem. These tillers which diverge so far from the mean create a problem in that they may be mistaken for a longer strawed variety when in reality they might be the result of a condition described by Engledow *et al* (*6*) as "the

TABLE 2.—*Length of tillers in inches.*

| Mid class Values | Lot 1 Normal Seeding | | Lot 2 18 inch Rows | | Lot 3 Plants 18 inches x 18 inches | |
|---|---|---|---|---|---|---|
| | (a) Mature | (b) Immature | (a) Mature | (b) Immature | (a) Mature | (b) Immature |
| 22.5 | | | | 1 | | 13 |
| 27.5 | | | | 2 | 7 | 18 |
| 32.5 | | 6 | | 4 | 45 | 34 |
| 37.5 | 1 | 22 | | 21 | 44 | 20 |
| 42.5 | 33 | 65 | 21 | 37 | 4 | 8 |
| 47.5 | 65 | 7 | 54 | 29 | | 7 |
| 52.5 | 1 | | 25 | 5 | | |
| Range | 39.5—50.0 | 31.5—46.0 | 41.0—54.5 | 24.0—52.0 | 25.5—40.5 | 14.5—46.0 |
| Mean | 45.90±3.095 | 40.65±2.742 | 47.70±3.217 | 42.50±2.867 | 34.75±2.344 | 33.15±2.236 |
| Standard Deviation | 2.450±0.117 | 3.500±0.117 | 3.380±0.161 | 5.475±0.261 | 3.415±0.163 | 6.77±0.323 |
| Co-efficient of Variation | 5.34 | 8.61 | 7.09 | 12.88 | 9.83 | 20.42 |

TABLE 3. *Number of heads per plant.*

| Mid class Values | Lot 1 Normal Seeding | | Lot 2 18 inch Rows | | Lot 3 Plants 18 inches x 18 inches | |
|---|---|---|---|---|---|---|
| | (a) Mature | (b) Immature | (a) Mature | (b) Immature | (a) Mature | (b) Immature |
| 0 | 5 | 20 | 38 | 1 | | |
| 1 | 36 | 54 | 27 | 8 | 10 | 1 |
| 2 | 42 | 18 | 26 | 32 | 29 | 3 |
| 3 | 14 | 7 | 8 | 28 | 21 | 4 |
| 4 | 3 | | | 21 | 12 | 9 |
| 5 | | | 1 | 4 | 14 | 7 |
| 6 | | 1 | | 1 | 7 | 10 |
| 7 | | | | 3 | 2 | 7 |
| 8 | | | | 1 | 2 | 14 |
| 9 | | | | | 1 | 12 |
| 10 | | | | 1 | 2 | 10 |
| 11 & over | | | | | | 18 |
| Range | 0—4 | 0—6 | 0—5 | 0—10 | 1—10 | 1—21 |
| Mean | 1.74±0.117 | 1.17±0.079 | 1.180±0.080 | 3.05±0.206 | 3.50±0.236 | 7.52±0.507 |
| Standard Deviation | 0.867±0.041 | 0.939±0.045 | 1.090±0.052 | 1.551±0.074 | 1.977±0.094 | 2.659±0.127 |
| Co-efficient of Variation | 49.83 | 80.26 | 92.37 | 50.85 | 56.49 | 35.36 |

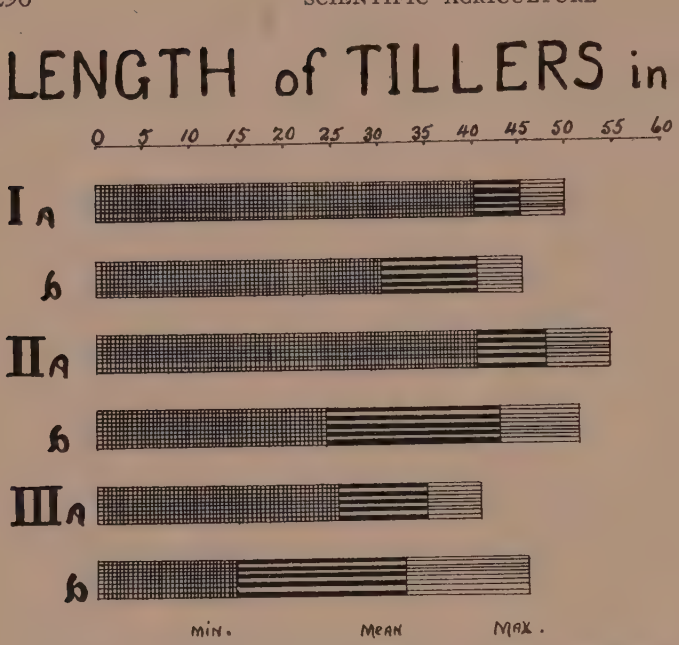


FIGURE 2. Length of tillers in inches. The range, minimum, mean and maximum length of tillers are represented.

chance synchronization of a weather-change and a sensitive development phase."

A further study of these data show that the mean height of Lot 2 is greater than Lot 1 but that the mean height of Lot 3 is less than that of Lot 1 or 2. This leads one to infer that the development of an excessive number of tillers may retard the development of length in the primary tillers. In other words the development of a greater number of tillers than the optimum represented in this case by Lot 2 results in a sacrifice in the length of the first tillers formed.

It will be observed that an increase in the number of tillers, Table 1, Lot 3, is associated with greater variation in length and a greater range between the minimum and maximum extremes. It seems quite possible for the tallest tillers to deviate so far from the mean that they are apt to raise a doubt in the mind of the observer as to their parentage when observed under field conditions.

### NUMBER OF HEADS PER PLANT

The number of heads per plant is of no particular significance except that it is an indication of the response of the variety to spacing. The groups were divided into two classes, mature and immature (designated "a" and "b" respectively in the tables) when the counts were made. Heads which were considered mature had fully developed grain and glumes turning yellow. Heads which had not progressed past the medium dough stage were considered as immature.

The data relating to the number of heads per plant are given in Table 3. A study of these data reveal the fact that there were plants in Lots 1 and 2 which did not have fully mature heads as well as plants which did not

have any immature heads. It will also be seen that the number of mature heads per plant was almost equal in these two groups; hence the principal difference in the number of heads per plant in these two groups consisted largely of immature heads. The heads carried on the main axes of the plants in these groups matured at approximately the same time. The apparent difference in maturity of these groups no doubt is due to the greater number of late maturing tillers in Lot 2. Had spacing influenced the maturity of the head borne on the main axis there would in all probability have been no mature heads produced in Lot 3. The fact that the heads borne on the primary tillers appeared to be of similar maturity and that there were more mature heads per plant produced in Lot 3 than in the other Lots is a further indication of late maturing tillers being responsible for the late and uneven maturity in wheat crops that have a thin stand.

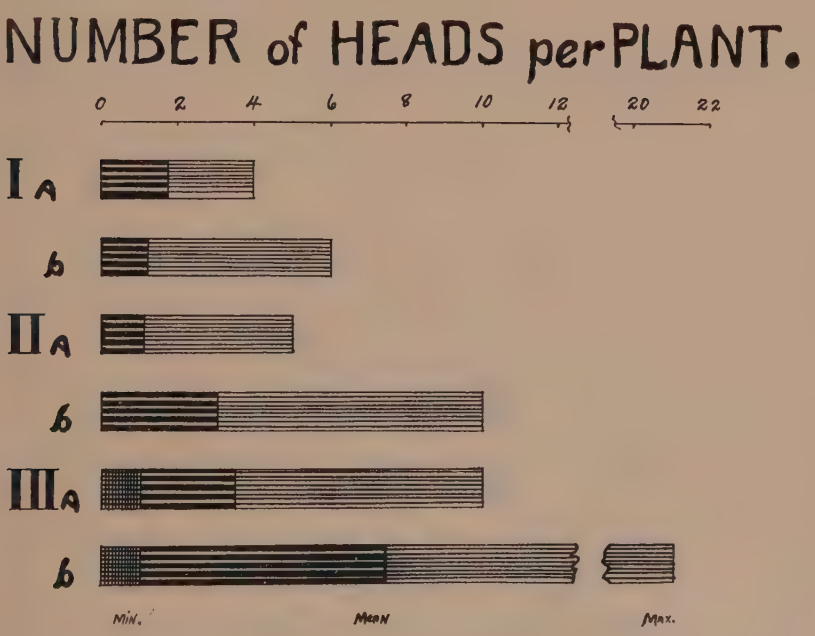


FIGURE 3. Number of heads per plant. The range, minimum, mean and maximum number of heads per plant are represented.

The range and standard deviation as shown in Table 3 and Figure 3 indicate that the variation in the number of heads per plant is more extreme as the plant is allowed more room to grow. It is rather surprising to find that the co-efficient of variation tends to become less in immature plants and as the plants are allowed more room. This is to be accounted for by the great increase in the mean in Lot 3 over the other lots and relatively much less increase in standard deviation.

The relative maturity of the heads of the three lots was not studied in a statistical way. Observations made indicated that the relative maturity of the primary tillers showed but little variation, but had the immature tillers been included and means and ranges established there would have been considerable variation in the three lots as the maturity of the tillers in Lot

3 varied all the way from fully mature to the flowering stage. It would appear as though a wheat plant, providing environmental conditions were favorable, would continue to send out tillers indefinitely, each successive tiller being a little later "physiologically as well as chronologically." It therefore seems reasonable to assume that one should allow considerable latitude in maturity and related factors when considering fields growing under conditions which favor the development of late maturing heads.

### Length of Heads

The measurement for length of head was made from the base of the lowest spikelet to the tip of the uppermost spikelet. The apical awns were not included in the measurement.

Table 4. *Length of head in m m.*

| Mid class Values | Lot 1 Normal Seeding (a) Mature | Lot 2 18 inch Rows (a) Mature | Lot 3 Plants 18 inches x 18 inches (a) Mature | (b) Immature |
|---|---|---|---|---|
| 55 | | | | 1 |
| 65 | 1 | | | 4 |
| 75 | 21 | 9 | | 11 |
| 85 | 39 | 19 | | 25 |
| 95 | 34 | 29 | | 38 |
| 105 | 5 | 30 | 1 | 11 |
| 115 | | 11 | 11 | 7 |
| 125 | | 2 | 52 | 3 |
| 135 | | | 32 | |
| 145 | | | 4 | |
| Range | 65—105 | 75—125 | 105—145 | 53—125 |
| Mean | 87.10±5.875 | 97.10±6.549 | 127.70±8.613 | 92.10±6.212 |
| Standard Deviation | 8.637±0.412 | 11.941±0569 | 7.463±0.356 | 13.364±0.644 |
| Co-efficient of Variation | 9.92 | 12 30 | 5.84 | 14.51 |

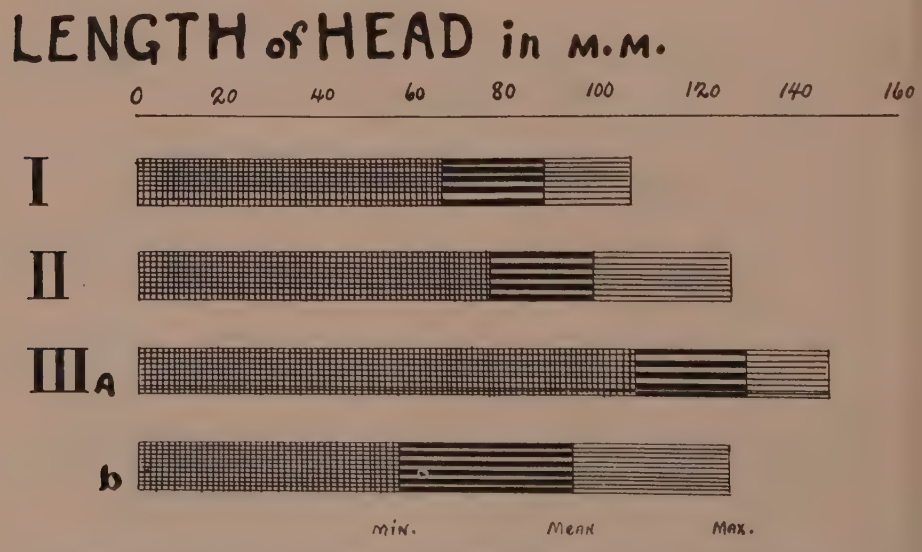


Figure 4. The length of head. The range, minimum, mean and maximum length of head are represented.

The variation in length of head itself is of no particular significance. It might naturally be expected that an increase in the length of head would be

associated with an increase in the length and number of tillers per plant. Length of head when associated with density of head, however, is one of the most important characters used in differentiating wheat varieties.

The data relating to length of head given in Table 4, and illustrated in Figure 4, show that there is great variation in this character. Not only is there great variation between groups but there is an even greater range of variation within a group. The great range of variation in length of head in the variety as a whole is indicated by the minimum of 55 m.m. and the maximum of 145 m.m. It is rather interesting to find that although the immature heads of Lot 3 are by far the most variable in length, the mature heads of the same Lot are less variable than the mature heads of Lot 2. The mean length of head data show that the length of the head increases as the distance between plants becomes greater.

### Number of Spikelets per Head

No separation of fertile and infertile spikelets was made in this study. It was observed that infertile spikelets were practically absent in Lot 3, that they would average approximately one per head in Lot 2, and approximately three per head in Lot 1. The total number of spikelets per head less the number of infertile spikelets would have shown greater differences among the different groups.

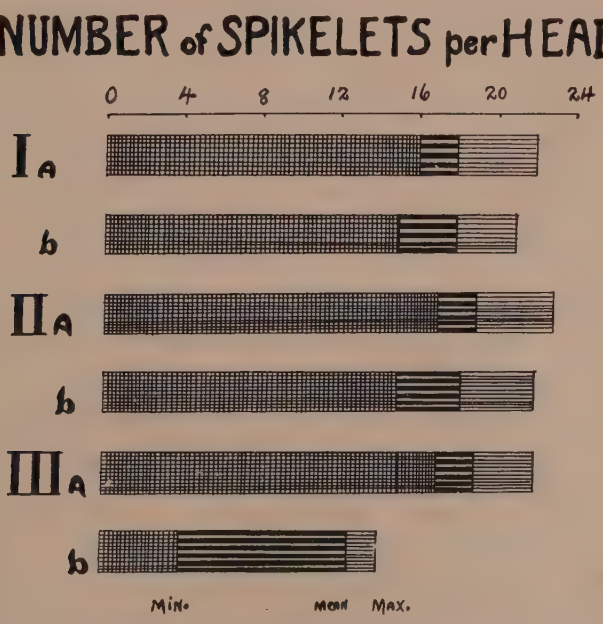


Figure 5. Number of spikelets per head. The range, minimum, mean and maximum number of spikelets per head are represented.

The data collected in studying this character provided a surprise in that the number of spikelets in the mature heads appeared to be relatively constant, irrespective of length of head and the spacing of the plant on which it was borne. The slight variation in the means of this class, as shown in

TABLE 5.—*Number of spikelets per head.*

| Mid class Values | Lot 1 Normal Seeding | | Lot 2 18 inch Rows | | Lot 3 Plants 18 inches x 18 inches | |
|---|---|---|---|---|---|---|
| | (a) Mature | (b) Immature | (a) Mature | (b) Immature | (a) Mature | (b) Immature |
| 9 | | | | | | 8 |
| 11 | | | | | | 30 |
| 13 | | | | | | 38 |
| 15 | 1 | 1 | | 5 | | 21 |
| 17 | 16 | 44 | 3 | 37 | 8 | 3 |
| 19 | 75 | 54 | 86 | 49 | 80 | |
| 21 | 8 | 2 | 10 | 9 | 12 | |
| 23 | | | 1 | | | |
| Range | 16—22 | 15—21 | 17—23 | 15—22 | 17—22 | 4—14 |
| Mean | 18.80±1.268 | 18.10±1.221 | 19.22±1.296 | 18.24±1.230 | 19.08±1.287 | 12.62±0.851 |
| Standard Deviation | 1.038±0.050 | 1.072±0.051 | 0.794±0.038 | 1.436±0.068 | 0.890±0.042 | 1.912±0.091 |
| Co-efficient of Variation | 5.52 | 5.92 | 4.13 | 7.89 | 4.66 | 15.15 |

Table 5 and illustrated in Figure 5, indicates that the number of spikelets per head is one of the most constant characters studied.

There appeared to be a relationship between the number of spikelets per head and the maturity: the later the maturity of the head the smaller appears to be the number of spikelets. It would seem as though each successive tiller produced was a little later in maturity and developed a correspondingly smaller number of spikelets than the preceding.

Table 5 and Figure 5 show that in all cases the number of spikelets on the immature heads is less than on the mature heads and that the range, standard deviation and co-efficient of variation are highest in the immature heads.

## Density of Head

The length in m.m. of the ten lower internodes of the spike was taken as a value to represent the density of the head.

The density of the head is of particular significance in the differentiation of varieties and strains of wheat. The study of this character is of particular interest in this case as it proved to be extremely variable. The range, as given in Table 6, shows that some heads are almost twice as lax as others in the same group.

Table 6 and the graph in Figure 6 show the variation in the density. It will be seen that the mean length of the ten lowest internodes increases as the plants are allowed more room to develop. Since the length of head increases as the interspace between plants increases and since the number of spikelets is fairly constant on all fully developed heads, it would seem as though there was a correlation between density and length of head. The density varies inversely as the length of the ten lowest internodes and also inversely as the length of the head.

Table 6.—*Density of head in m.m.*

| Mid class Values | Lot 1 Normal Seeding (a) Mature | Lot 2 18 inch Rows (a) Mature | Lot 3 Plants 18 inches x 18 inches (a) Mature | (b) Immature |
|---|---|---|---|---|
| 32.5 | 5 | | | |
| 37.5 | 28 | 17 | | |
| 42.5 | 29 | 19 | | |
| 47.5 | 35 | 24 | | 2 |
| 52.5 | 3 | 31 | | 4 |
| 57.5 | | 7 | 4 | 3 |
| 62.5 | | 2 | 18 | 24 |
| 67.5 | | | 39 | 36 |
| 72.5 | | | 24 | 23 |
| 77.5 | | | 11 | 6 |
| 82.5 | | | 4 | 2 |
| Range | 32—50 | 35—60 | 57—83 | 46—85 |
| Mean Standard | 29.15±1.966 | 47.40±3.197 | 69.10±4.661 | 67.05±4.523 |
| Standard Deviation | 4.871±0.232 | 6.403±0.305 | 5.655±0.269 | 6.480±0.309 |
| Co-efficient of Variation | 16.71 | 13.51 | 8.18 | 9.07 |

The relationship between density and length of head is not constant between individual plants nor between individual heads on the same plant; for example, one case was found where the immature heads on one plant varied in density from 4.7 to 8.2 while two heads of similar length produced by this same plant—see Figure 10A—exhibited a wide range in density,

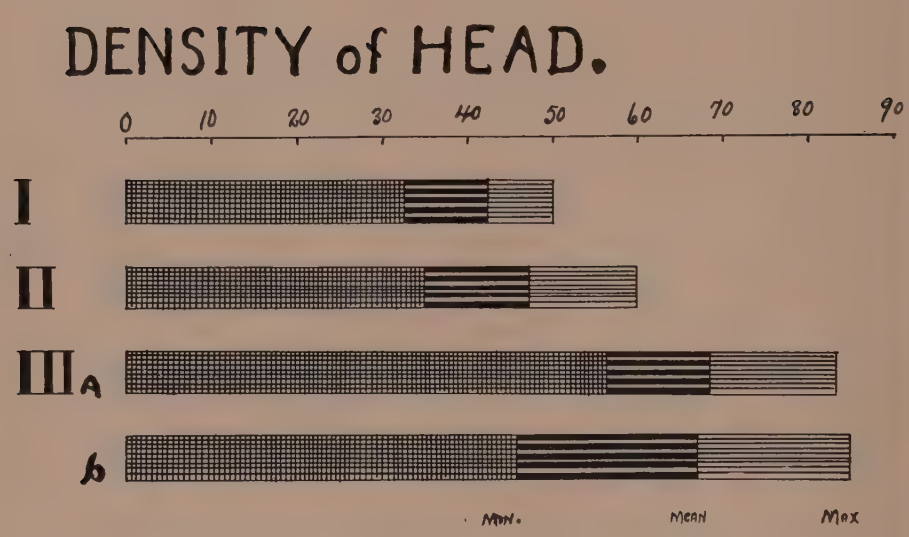


FIGURE 6. Density of head. The range, minimum, mean and maximum density of head are represented.

being 120 m.m. long and with a density of 64 m.m. in the one case against 135 m.m. long with a density of 80 m.m. in the second. It will be seen that these extreme combinations might cause considerable difficulty were varieties differentiated by this character alone.

In speaking of density of head Newman (*9*) describes Marquis as "mid-dense under normal conditions, but under other conditions may be fairly lax or quite dense." In speaking of density of head in general Newman states, "The density of the spike is affected very appreciably by the general development of the plant. Spikes which are abnormally developed, as often is the case along the margin of fields or plots, are likely to be more open or 'lax' than are those which have developed normally. Similarly, heads which are subnormal in development, as when borne on late developing tillers, are likely to be more dense. It is important, therefore, to note the general development of the plant before taking the density of spike into consideration and even then there is some danger of attaching too much importance to so variable a character, although the latter often may be of considerable assistance." His statements are in agreement with the findings of this investigation.

## GLUMES

The glume is a very important plant character in wheat variety and strain differentiation. There has been considerable discussion during the past five years concerning the variability of this character. To date, very little definite knowledge is available, although opinions are rampant.

The length of glume was studied in a statistical way. The glume selected on each head for measurement was the secondary glume of the fourth fertile spikelet from the base of the spike. The measurement for length of glume was taken from the base of the glume to the base of the beak or to the point of greatest angularity where the beak and shoulder join

The measurement was made by placing one point of a caliper at the base of the glume and the other point at the base of the beak; this measurement was transferred to a metric scale and recorded.

The related data in Table 7 and Figure 7, when analysed, show that the mean length of the glume increases from Lot 1 to Lot 3 and that the mean length of the glumes of the immature heads of Lot 3 is greater than the length of the glumes of the mature heads of the same group. While there is a slight difference in the mean length of the glumes of the different lots, the co-efficient of variation indicates that glume length is the least variable of the characters studied.

TABLE 7.—*Length of glume in m.m.*

| Mid class Values | Lot 1 Normal Seeding (a) Mature | Lot 2 18 inch Rows (a) Mature | Lot 3 Plants 18 inches x 18 inches (a) Mature | Lot 3 Plants 18 inches x 18 inches (b) Immature |
|---|---|---|---|---|
| 7.0 | 1 | | | |
| 7.5 | | 1 | | |
| 8.0 | 30 | 17 | 2 | 2 |
| 8.5 | 21 | 14 | 12 | 1 |
| 9.0 | 48 | 63 | 69 | 49 |
| 9.5 | | 2 | 10 | 23 |
| 10.0 | | 3 | 7 | 25 |
| Range | 7.0—9.0 | 7.5—10.0 | 8.0—10.0 | 8.0—10.0 |
| Mean | 8.575±0.578 | 8.785±0.593 | 9.04±0.610 | 9.34±0.630 |
| Standard Deviation | 0.460±0.022 | 0.438±0.021 | 0.379±0.018 | 0.299±0.014 |
| Co-efficient of Variation | 5.36 | 4.99 | 4.19 | 3.20 |

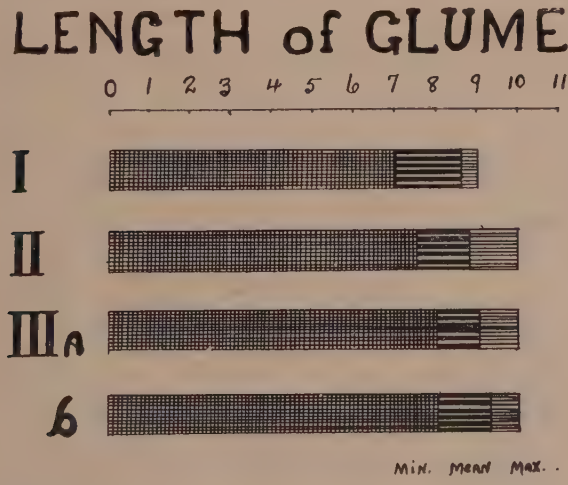


FIGURE 7. Length of glume. The range, minimum, mean and maximum length of glume are represented.

A study was made of the effect of maturity on the shape of the glume. It was observed that the glume of Marquis wheat progresses through certain stages of development coincident with the progression of the maturity of the plant from the flowering stage to the fully developed kernel. These

FIGURE 8. Glumes of Marquis 10B wheat illustrating the changes noted in the shape of the glume as the plant progresses from the flowering stage (A) to full maturity (D).

successive stages of development are illustrated in Figure 8. A. represents the contour of a typical glume during the flowering stage of the plant. The glume at this stage is upright in growth and has a slightly elevated shoulder. B. represents the shape of the glume after the kernel has started to develop. The glume has broadened out and the shoulder is more nearly at right angles to the beak. C. represents the glume when the kernel is fully grown in size but is still in the watery stage. The increase in the size of the kernel has bent the glume backward and a buckle develops near the base of the keel. The bending backward apparently changes the whole contour of the glume. It will be seen that as the glume is forced backward the outer point of the shoulder is pulled downward by a shearing movement, thus changing the angle of the shoulder from a slightly elevated to a slightly oblique position. D. represents a fully matured glume from a spikelet that bore four or more

FIGURE 9. Heads of Marquis 10B wheat showing the variations in the number of fertile and infertile spikelets, length and shape of head.

fully matured kernels. It will be seen that a decided buckle has developed near the base of the keel, that the obliqueness of the shoulder is quite pronounced, and that the glume appears both shorter and broader. Mature glumes from spikelets which have borne two to three kernels would be similar to B. and C. except that they tend to broaden out in the centre. This observation is in agreement with Newman's (*9*) description of Marquis wheat. In describing glume shape he states "Shoulder of empty glume of secondary floret on seventh node from base of spike, square to slightly elevated under normal conditions. Under conditions which force an abnormal growth and more open head the shoulder of the glume is likely to be quite oblique, while under sub-normal conditions the shoulder may be decidedly elevated."

FIGURE 10. A. Two heads of Marquis 10B wheat taken from the same plant showing extreme variation in density. B. Plant of Marquis 10B wheat showing extreme variation in length of tiller. The group of tillers on the left are fully matured and are shorter and less variable in length than the group of immature tillers on the right.

## CONCLUSIONS

1. The tiller of the Marquis wheat plant may be very variable in length and maturity. While the earliest maturing tillers are usually taller, cer-

tain later maturing tillers, when environmental conditions are favorable, may grow so much taller than other tillers on the same or adjoining plants that they at once raise a doubt in the mind of the observer as to their parentage.

2. The heads of Marquis wheat plants, when grown under varying environmental conditions, show a wide range in length, shape, density and general appearance. They may vary so much that it would be difficult for anyone not intimately acquainted with Marquis type to identify heads grown under different environmental conditions, as being genuine Marquis.
3. Glume length appeared to be the most constant of the characters of Marquis wheat studied.
4. The glume progresses through certain stages of development coincident with the progression of the maturity of the plant from the flowering stage to the fully developed kernel.
5. In view of the extreme variation in Marquis wheat which appears to be directly attributable to differences of environment and maturity, it is essential that heads of similar maturity and grown under similar environmental conditions should be selected for strain comparisons.
6. The data presented in this paper indicate that Marquis 10 B wheat in particular is subject to a wide range of "fluctuation" or "variation from the mean" variety type, and suggests the likelihood that other strains of Marquis and other varieties of wheat are also subject to extreme variations in morphological characters when grown under varying conditions of environment.
7. While the foregoing conclusions are the result of several years of general observations and of the interpretation of considerable data, the statistical study is the result of one year's work only. The problem is undoubtedly important enough to warrant further study, either to substantiate or to modify the conclusions drawn.

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# THE PROFILE OF A COMMON SANDY SOIL TYPE IN NORFOLK COUNTY, ONTARIO*

F. F. Morwick†‡
*Ontario Agricultural College, Guelph, Ont.*

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The extent of technical soil studies in Ontario is not as great as in many states in the U.S.A. or in many countries on the European continent, although considerable work has been done.

Before making a detailed study of any one type of soil or any one local area, it is desirable to have some knowledge of the area as a whole. For this reason the preliminary soil survey of Old Ontario was started in the summer of 1914. The work was new to those in charge and many difficulties were encountered, but considerable progress was made during the next six years. This preliminary work was reported in a bulletin (*8*) published by the Ontario Department of Agriculture in June, 1923.

In the latter part of the summer of 1922 a start was made on the more detailed survey of the soils of Kent County. Since that time the work has been carried on in Kent and Essex Counties, the Niagara Peninsula and Norfolk County, in the order given. The soils were classified and mapped according to differences in origin of parent material, mode of deposition, texture, reaction, colour, organic matter content, topography, drainage, etc. With the aid of a soil auger and a narrow spade the soils were examined to a depth of three or four feet and in many cases deeper. In sampling the various types, in Kent and Essex Counties, the samples were taken from certain definite depths, from the surface downward, regardless of changes in colour or texture.

As the work proceeded new information was secured, both from the work itself and from the findings of soil investigators elsewhere. During the past few years there has been a tremendous amount of soil research work accomplished, and there has also been a considerable change in the conception of soil problems.

In this new conception of soils, which originated among Russian workers, the soil or soil "profile" includes the whole thickness upon which the soil-forming processes have operated. Definite layers or horizons can be distinguished and are recognized. This new conception of the soil profile has largely been accepted as a basis for soil classification. It has necessitated a change in the methods of sampling. A sample of a soil, according to this classification, includes a representative sample from each layer or horizon in the profile, regardless of its depth.

Before beginning the discussion of this particular type of Ontario soil, a brief survey of some of the work which has already been done on similar regional profiles will be given in the following few paragraphs.

*Part of thesis submitted for the degree of Master of Science in Agriculture taken in the Department of Chemistry, Ontario Agricultural College, Guelph.

†Specialist in Soil Surveys.

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## Review of Literature

Glinka (*5*) was one of the pioneers in this work. He concluded that the degradation of forest chernozem soils into podsol soils was due to the excessive moist conditions accompanying forest vegetation. The calcium carbonate is leached out of the humus in the surface strata, and the humus passes into solution and is carried to the subsoil with the finest materials, which are rendered dispersible.

At a later time American investigators took up the study of soils from the standpoint of the soil profile. McCool, Veatch and Spurway (*9*) divided the soils of Michigan into two general groups, the Northern and the Southern, according to the general characteristics of the soil profiles. They concluded from their investigations that the soil profile as a whole was the unit to be studied in plant adaptation and soil management, and that soils should be sampled with respect to their profiles rather than by linear depths. Following this, McCool and Weidemann (*10*) carried on further studies on the colloidal content of the various horizons and also a study of several organic soil profiles (*11*). In the same year Wheeting made a comprehensive study of five soil types from the State of Michigan (*20*). He referred to the work of Glinka (*6*), who placed the Brown soils in the same major group as the Podsol soils and stated that two conditions seemed always to accompany the formation of the profile of the Brown soil—first, the presence of forest vegetation and second, the presence of lime carbonate in the parent rock flour. The normal, mature profile, developed in regions where the Brown soils occur, is given by Marbut as follows:—

"*Horizon 1* ($A_0$) Forest debris, consisting of leaves at the surface and forest mold or mull below, usually mixed with dark coloured earth due to the work of insects and worms.

*Horizon 2* ($A_1$) Dark brown horizon, consisting of a brown mineral soil material mixed with forest mold. It ranges up to three or four inches.

*Horizon 3* ($A_2$) Brown horizon, often with yellowish shade, ranging up to eighteen inches in the medium textured soils and deeper in the sands.

*Horizon* 4 (B) Reddish brown to yellowish brown horizon, heavier than any of the overlying horizons, the reddish brown colour being more common in the lighter textured soils.

*Horizon 5* (C) Parent material, usually partially weathered at the top."

In Wheeting's study of five soil profiles from the State of Michigan he found good evidence of podsolization processes, resulting in the transfer and accumulation of material, both mechanical and chemical. All five profiles were developed from calcareous drift. The B horizon is the layer of accumulation and the one above it is the leached layer. It appears that the presence of calcium carbonate in the original drift is necessary for the reprecipitation of this material in the process of translocation. In some cases coarse parent material has been changed to a comparatively fine state of subdivision while in other types a soil has developed which is coarser in texture than the parent drift. Also in some cases an acid profile has developed, while in others the entire profile has remained alkaline.

Millar (*12*) carried on some pot experiments to show the feeding-power of plants in different soil horizons. He found that with oats the yields on all the lower horizons were inferior to those on the surface horizon, but with sweet clover the yield was much better on the lower horizons. He partly attributed this difference to the difference in lime requirements for the two crops.

Edgington and Adams (*4*) carried on an investigation of the distribution of nitrogen in the podsol profile, on samples taken from New Hampshire. They found the nitrogen content very high in the organic layer, low in the $A_2$ horizon, increasing markedly in the B horizon and falling off sharply in the C horizon. The acidity of the different horizons varied, but had a tendency to be lowest in the $A_2$ horizon. There was much more fine material in the B horizon.

Veatch (*18*) made a general study of Michigan soils. He states that in soil profile studies it has been found in general:—

"1. That the surface layer of the virgin soil, in which there has been an accumulation of humus, is higher in the elements of fertility and less strongly acid, particularly in the heavier soils, than the horizon of mineral soil directly beneath it.

2. That there is a horizon of variable thickness, which lies just beneath the mold or humus soil, which represents maximum leaching and removal of the more soluble constituents, while at a shallow depth the soil reaches a maximum acidity.

3. That lime or $CaCO_3$ has been leached or removed generally to depths of two to six feet; that the removal has taken place to greater depths in sands than in clays; that the substrata are universally calcareous or alkaline in reaction.

4. That there is a horizon at variable depths, but above the substratum, in which there is a maximum amount of clay and colloids due either to weathering in place or concentration of both.

There are four general types of profiles: —

(1)

(2)

(3)

(4)

A knowledge of the virgin soil enables us to understand better the changes which have taken place in the plow soil due to cultivation. Often horizon "three" comprises a large part of the plow soil, due to erosion of horizons "one" and "two". In most soils the plow soil is a mixture of two or three horizons."

Ogg and Dow (*13*) made an extensive study of Scottish soils. Their results indicate leaching of the surface layers, owing to the humid climate, which supports the view that Scottish soils in general belong to the Podsol group.

### Identification of Type and Mapping of Area

In the survey of the soils of Norfolk County, the soil type discussed in this paper, along with the other types found, was identified by its general characteristics such as profile development, colour of horizon, texture, reaction, drainage, vegetation, etc. A cross-section of the profile was frequently examined by digging a small pit with a narrow spade or by cutting back in a bank along a roadside, railway cut or gravel pit, etc., to get a freshly exposed surface. The reaction of the various horizons was determined in the field by the colorimetric method, using brom-thymol blue as indicator. The boundaries of the various types were located and drawn on a base map, with a scale of one inch to one mile, which will be published with the detailed report of the Norfolk County soils.

The profile of this type has somewhat the same general characteristics as that of the Brown soils described by Marbut in Wheeting's bulletin (*20*) except that the $A_0$ and $A_1$ horizons are more or less mixed together. The same profile is also described by Veatch (*18*) in his second general type.

Cross section showing profile development.

$A_1$ horizon or surface soil. 5 to 8 inches.

$A_2$ horizon or leached layer 16 to 24 inches.

B horizon or layer of accumulation 4 to 6 inches.

C horizon or parent material.

In general this is a medium to coarse-textured sand, fairly low in organic matter content. It has a greyish brown surface soil, a yellowish brown leached layer, a well-developed reddish brown layer of accumulation and a calcareous grey sandy or gravelly parent material. These four horizons or soil layers can easily be distinguished in the accompanying photograph (Figure 1) which was taken from a virgin profile in a location just west of the village of Teeterville.

FIGURE 1. Showing the four horizons of this soil profile: $A_1$—Surface soil; $A_2$—Leached horizon; B—Layer of accumulation; C—Parent material.

In cultivated fields the $A_1$ and $A_2$ horizons are slightly acid, but in the virgin soils the profile is usually alkaline throughout. The depths of the various horizons vary considerably, even within a few feet in many instances. This irregularity of depth is clearly shown in Figure 2 which is a photograph taken from a virgin profile about one mile southwest of the village of Delhi.

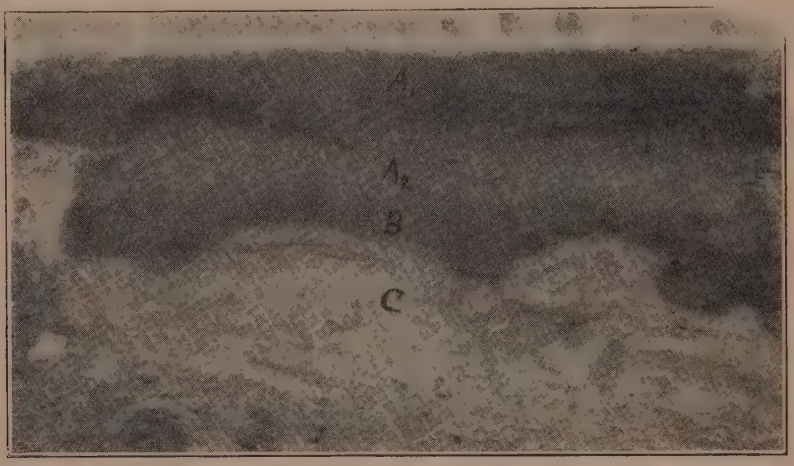


FIGURE 2.—Showing the irregularity of depth of the various horizons in the soil profile.

The depths of the different horizons vary considerably but within the following approximate limits:—

$A_1$ - 4 to 7 inches, grey brown surface soil.
$A_2$ - 12 to 27 inches, yellow brown leached layer.
B - 3 to 7 inches, reddish brown layer of accumulation.

The lines of demarcation between the $A_1$ and $A_2$ horizons and between the $A_2$ and the B horizons are often rather indistinct or gradational but the line between the B and C horizons is quite distinct and abrupt. This characteristic may be noted in Figure 2. The B horizon is quite sticky or plastic and when left exposed to the sun it bakes quite hard. The horizons are all well-marked and there is very little streaking or mottling of colour.

The topography is slightly rolling and the natural drainage is very good.

## THE SELECTION AND PROCURING OF SAMPLES

In collecting the samples, the general suggestions of the Committee on Sampling, appointed by the American Soil Survey Association, were strictly followed.

The locations from which samples were taken were selected from areas which were most representative of the type. A sample was taken from a virgin profile in the immediate vicinity of each sample taken from a cultivated field. The samples from virgin soil were secured from woodland areas or along line fences. In every instance, great care was taken to secure locations which were not influenced by excessive, unnatural agencies such as excessive applications of fertilizers or continued applications of limestone dust, for example, areas covered with dust blown from heavily travelled stone roads.

Fourteen samples were taken from locations in Norfolk County, seven from virgin soils and seven from cultivated soils. For comparison and correlation two samples were taken from locations on the same soil type in cultivated fields in Essex County.

## Laboratory Procedure and Methods

The samples were air-dried at ordinary room temperature. They were then pulverized, where necessary, with a hard rubber pestle and mortar and sifted through a one-millimeter sieve and the two separates weighed. The results were recorded as the percentage of material which would pass through a one-millimeter sieve.

*Reaction:* The pH values were determined by the electrometric method, using Biilmann's quinhydrone electrode (*2*).

*Colloidal Material:* The percentage of colloids was determined by the new hydrometer method as outlined by G. J. Bouyoucos (*3*).

*Organic Matter:* The percentage of organic matter was determined by the rapid approximate method described by Schollenberger (*14*). This method is based upon the well known wet combustion method for total carbon and upon the commonly accepted average of about 50 per cent carbon and 5 per cent nitrogen in the organic matter of the usual soil types.

The results of the laboratory determinations are given in the following four tables:—

Table 1.—*Percentage of material under 1 mm. diameter.*

| Horizon | A | $A_2$ | B | C |
|---|---|---|---|---|
| Average of 7 virgin soils in Norfolk Co. | 96.1 | 96.9 | 91.7 | 95.4 |
| Highest | 99.5 | 98.9 | 98.9 | 99.5 |
| Lowest | 95.9 | 92.6 | 79.1 | 91.3 |
| Average of 7 cultivated soils in Norfolk Co. | 97.9 | 94.9 | 92 2 | 79.6 |
| Highest | 99.2 | 99.1 | 97.7 | 100 |
| Lowest | 96.3 | 85.2 | 84.4 | 61.3 |
| Average of 2 cultivated soils in Essex Co. | 81.9 | 69.2 | 68.3 | 60.6 |

As a general rule, the average size of the soil particles increases with depth, but this does not always hold true. The parent material is not always uniform in texture. Where large surfaces are exposed it shows a considerable amount of layering or sorting out of material, according to size of particles, thus indicating a water-laid deposit. There is no significant difference between the cultivated soils and virgin soils in this respect.

Table 2.—*pH values.*

| Horizon | A | $A_2$ | B | C |
|---|---|---|---|---|
| Average for 7 virgin soils in Norfolk Co. | 7.32 | 7.03 | 7.35 | 8.34 |
| Highest | 8.02 | 7.44 | 7.55 | 8.50 |
| Lowest | 6.59 | 6.55 | 7.00 | 8.17 |
| Average for 7 cultivated soils from Norfolk Co. | 6.31 | 6.62 | 7.18 | 8.38 |
| Highest | 6.86 | 7.25 | 7.41 | 8.50 |
| Lowest | 5.81 | 6.31 | 6.87 | 8.23 |
| Average for 2 cultivated soils from Essex Co. | 6.54 | 6.59 | 7.09 | 8.25 |

While there is some variation in individual samples, the average results on the virgin profiles agree very closely with the findings of Veatch (*18*)

on Michigan soil profiles, and with Edgington and Adams (*4*) on podsol soils from New Hampshire, in that the region of maximum acidity is in the $A_2$ or leached horizon.

The cultivation and cropping of the soil seems to have caused considerable increase in the acidity of the upper layers. In the cultivated soils, the region of maximum acidity appears to be in the surface layer. The leached layer is nearly as acid as the surface layer ,and is much more acid than the corresponding layer in the virgin profile. The layer of accumulation is slightly alkaline, but still has a lower pH value than the same layer in the virgin profile. The parent material has approximately the same pH value in both the virgin and cultivated soils.

These results, on the comparison of pH values of virgin and cultivated soils, are opposite to the results found by Ogg and Dow (*13*) in a similar comparison of Scottish soils. They found an increase in pH values in the surface soils of cultivated fields, which they attributed to the mixing up of the subsurface layers in cultivation, and to heavy applications of lime. They, however, were working with soils which were much more strongly acid in the virgin state. Heavy applications of lime were necessary in their agricultural practice.

With this type of soil the practice of applying lime has been unnecessary. The increase in acidity of the surface layers can be explained by the removal of lime by growing crops.

TABLE 3.—*Percentage of colloidal material.*

| Horizon | $A_1$ | $A_2$ | B | C |
|---|---|---|---|---|
| Average for 7 virgin soils in Norfolk Co. | 9.74 | 7.66 | 16.34 | 2.70 |
| Highest | 11.60 | 9.45 | 26.40 | 3.42 |
| Lowest | 6.30 | 6.25 | 12.15 | 2.00 |
| Average for 7 cultivated soils in Norfolk Co. | 8.33 | 7.75 | 17.27 | 2.73 |
| Highest | 9.30 | 12.10 | 21.83 | 3.75 |
| Lowest | 7.65 | 5.70 | 11.35 | 2.00 |
| Average for 2 cultivated soils in Essex Co. | 11.01 | 11.95 | 18.30 | 2.55 |

There is no appreciable difference in the colloidal content of the corresponding horizons in the virgin and in cultivated soils. The $A_2$ horizon is usually slightly lower in colloidal matter content than the $A_1$ horizon; a maximum is attained in the B horizon; and a very small amount is present in the parent material. The high colloidal content in the B horizon is a very important factor in controlling the moisture supply in this type of soil.

TABLE 4.—*Percentage of organic matter.*

| Horizon | $A_1$ | $A_2$ | B | C |
|---|---|---|---|---|
| Average for 7 virgin soils in Norfolk Co. | 2.66 | .39 | .39 | .21 |
| Highest | 3.10 | .48 | .89 | .29 |
| Lowest | 2.30 | .21 | .22 | .13 |
| Average for 7 cultivated soils in Norfolk Co. | 1.19 | .28 | .39 | .23 |
| Highest | 1.51 | .43 | .46 | .29 |
| Lowest | .72 | .20 | .31 | .16 |
| Average for 2 cultivated soils for Essex Co. | 1.06 | .28 | .39 | .28 |

The maximum amount of organic matter was found in the surface soils of the virgin profiles. There was a very much smaller amount in the $A_2$ horizon, in most cases a slight increase in the B horizon, and the smallest amount in the C horizon. In the cultivated soils there was about half as much organic matter in the surface layer, as in the surface layer of the virgin soils; in the $A_2$ horizon there was slightly less in the cultivated soils than in the virgin soils; the amounts in the B and C horizons were practically the same as in the virgin soils. This indicates that cropping has removed a large part of the organic matter from the upper layers of the cultivated soil.

## Comparison of Norfolk and Essex Samples

Owing to the small number of samples from Essex County, no definite conclusions can be drawn, but both the field observations and the laboratory results indicate that the soil profile in each of the two areas has the same general characteristics.

## Geological Relationships

According to geological records (*16*), this part of Ontario is covered by rock of the Devonian age. The basal Devonian, which lies at the surface in the eastern part of Norfolk County, lies under 500 feet of other rock at Lynedoch, 20 miles distant. The rock, therefore, has a westward dip of 25 feet per mile, since the surface elevation is relatively constant. From the record of a well drilled at Lynedoch in 1910 there is 195 feet of drift and surface material covering the Delaware limestone, which is the upper rock formation at this point.

The drift and surface material was deposited by the ice, during and at the close of, the period of glaciation (*19*). The area discussed in this paper is just west and northwest of the Paris moraine, or between the Paris moraine and the eastern portion of the Tillsonburg moraine (*17*). The upper portion of the glacial drift material, in this soil type, shows a distinct layering according to size of particles. This indicates that the material has been re-worked by water, since it was deposited by the retreating, melting ice. It, no doubt, consists of outwash material from the nearby moraines.

Big Creek has eroded its channel down through this district and affords an excellent, natural, drainage outlet for all this area.

## Vegetation Relationships

In 1927 Hanson and Smith (*7*) carried on an investigation into the relationship between some types of vegetation and the soil profile in Northern Colorado. They found that such a relationship existed. For example, they found that the depth and hardness of the hardpan layer, or layer of accumulation, was indicated by the character and density of the vegetation.

On the type of soil discussed in this paper, there is an abundance of fences built from pine stumps, thus indicating that the previous vegetation consisted largely of pine. The natural, present vegetation consists mainly of white pine (*Pinus strobus*), oak (*Quercus alba* and *Quercus rubra*) and hazelnut (*Corylus dentate*).

In the Leamington area, in Essex County, where the two samples were taken, they have been successfully growing flue-cured tobacco for about fifteen years. This crop was first grown in Norfolk County about five years ago, in the vicinity of Lynedoch. Since that time the cultivation of this crop has spread rapidly in the county. While some growers are locating on types of sandy soils which do not conform exactly to the type described in this paper, most of the older and more experienced growers are choosing this type. This would indicate that this type of soil is best adapted to the growth of flue-cured tobacco.

The climatic condition is a limiting factor in the growth of this crop also. It has not yet been grown in the northern part of the county. The frost-free period is several days shorter in the Delhi district than in the Leamington district. The latitude of the area of this type of soil in Norfolk County is between 42 degrees 45 minutes and 43 degrees, while the latitude of the Leamington district is about 42 degrees 5 minutes.

FIGURE 3. A photograph of a field of growing flue-cured tobacco in the Delhi District, taken in July, 1928.

## SUMMARY

1. Recent investigations of soil scientists have shown that the soil profile, as a whole, is the unit to be studied in plant adaptation and soil management.
2. This type of soil was identified, mapped and described according to its general, field characteristics.
3. Samples were secured from both virgin soils and cultivated soils, from locations which were representative of the type. In each case a representative sample was taken from each horizon in the profile, and always from a freshly dug pit.

   Samples were also secured from the same type of soil in Essex County.
4. The degree of fineness, the pH values, the percentage of colloidal material and the percentage of organic matter of each of the samples were determined.

(a) The degree of fineness of soil particles in the various horizons was inconsistent. This is due to the fact that the parent material is not uniform in texture.

(b) The region of maximum acidity is in the $A_2$ or leached horizon in the virgin soils, and is in the surface horizon in the cultivated soils. The cultivated soils are more acid than the virgin soils.

(c) The maximum colloidal content is in the B horizon.

(d) Most of the organic matter present was in the surface layers. There was less in the cultivated soils than in the virgin soils.

5. This soil lies in the glaciated region and appears to be outwash material from the near-by morainic ridges.
6. The dominant natural vegetation is pine, oak and hazelnut.

## Conclusions

1. In general, this type of soil belongs to the Brown soils group, as described by Marbut (*20*).
2. The high content of colloidal material in the B horizon, is an important factor in controlling the moisture supply in a sandy soil, and hence, is important in crop adaptation.
3. This type of soil appears to be well adapted to the growing of fluecured tobaco.

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## BOOK REVIEW

Poultry Production. By William Adams Lippincott. (Lea and Febiger, Philadelphia. Fourth Edition, revised, pp. 602. Price $3.50).

Since 1921, when the third edition of Poultry Production appeared, University instruction in poultry husbandry has undergone marked changes at most institutions. Students are now given a thorough grounding in scientific principles rather than in empirical practices, and less attempt is made to teach skill in management which can only be acquired by practical experience. The change is fully reflected in the fourth edition of Dr. Lippincott's standard work, of which some sections have been entirely rewritten and all have been revised.

Greatest changes are evident in the two chapters dealing with breeding. In these, instruction in caponizing has been left out and more space is devoted to an excellent survey of the physiology of reproduction in the fowl. Principles of genetics are expounded and various characters in the fowl are used for illustrative material. The importance of the progeny test is emphasized and followed by a detailed description of the technique of pedigree hatching and recording performance.

The chapter on incubation has been greatly improved not only by incorporating the findings of recent investigations but also by referring freely to the older (but less known) researches of various European workers. The section dealing with nutrition and feeding has been brought up to date as has that on diseases. In these fields, Dr. Lippincott has enjoyed the cooperation of his associates at the University of California and the result is a well rounded out text.

Exponents of the all mash method of feeding laying stock may not be in entire accord with the author's statement that "The compelling of exercise is a part of the feeding routine". The reviewer regrets that such a standard text has adopted the recently innovated but entirely unnecessary expression "livability", as applied to chicks, when the language already provides the word "viability", which expresses the meaning more accurately. However, these are merely matters of opinion.

The chapters on turkeys, waterfowl, and pigeons have been eliminated in the fourth edition, but their loss is more than made up by the addition of a bibliography of 20 pages. As a text for university use, the book is the leader in its field.

F.B.H.

# NATURAL CROSSING BETWEEN WHITE FLOWERED AND YELLOW FLOWERED SWEET CLOVER

L. E. Kirk†
*University of Saskatchewan, Saskatoon, Sask.*

[Received for publication October 8, 1928.]

Those engaged in the breeding of sweet clover and others whose concern it is to produce pure seed of a given variety, will welcome any information on the extent of natural crossing between the white flowered and yellow flowered species of this important legume. In the absence of experimental evidence, it has been assumed generally that purity of variety can only be maintained by growing the crop at a sufficient distance from other sweet clovers to insure effective isolation against cross-pollination. It is a curious fact also that a cross between white flowered and yellow flowered sweet clover has never been reported.

With a view to securing something definite on this subject by way of experimental evidence, an experiment was begun six years ago, the results of which have become available only during the past summer.

## Experimental Procedure

A single eight rod row of white flowered biennial sweet clover ("Grundy County" variety) was sown and ten rows of yellow flowered sweet clover on either side, the rows spaced 36 inches apart. Each row of the latter was a different species or variety, there being at least five very distinct types represented. During the second year of growth, all of the clovers were cut when about two feet high in order that the blossoming would be concurrent for all kinds, as this invariably occurs with second growth sweet clover in our location. It was observed that the plants were visited during flowering by extraordinary numbers of honey bees, the nursery literally humming like a hive. This point is stressed to emphasize the exceptionally favorable conditions which existed for cross-pollination. Observation disproved the legend that bees will not visit flowers of different colours on the same day. On the contrary, they passed from white to yellow flower and from yellow to white indiscriminately.

When the seed of the white flowered plants was ripe, it was harvested by hand. The following year 11,400 plants were grown in an isolated field one half mile from the experimental plots on land which had never grown sweet clover before. The next season these plants were watched for hybrids which were expected to be yellow flowered since colour is usually dominant to white. Only 17 yellow flowered plants appeared one of which had cream coloured blossoms.

Seed of these 17 plants was saved and progenies grown from each to determine whether they were really hybrids or whether they had come from seed which had accidently gotten into the soil. The sowing was done in the spring of 1927 on clean soil and second generation progenies of 150 to 500 plants of each were obtained.

There was also the possibility that white flower colour and not yellow might be dominant, in which case hybrid plants could not be detected among the 11,400 plants. Having in mind this possibility, a few seeds were selected at random from each of a large number of the white flowered plants and

†Professor of Field Husbandry.

about 4,000 plants grown in 1927. If hybridization had occurred and if white flower colour turned out to be dominant, seed from a white flowered hybrid would segregate in the second generation and yellow flowers should be found among the 4,000 plants grown from the selected seed. It was considered that a sufficient number of white flowered plants had been sampled to detect one or two percent of natural crossing.

## Experimental Results

Only one of the progenies from the 17 yellow flowered plants showed segregation for yellow and white flower colour, the other 16 giving none but yellow flowered plants. Those that did not segregate were deemed to be accidental mixtures, whereas the segregating progeny resulted from the only hybrid among 11,400 plants. The percent of natural crossing in this experiment was therefore less than one-hundredth of one percent.

Among the 4,000 plants grown from seed selected at random from white flowered plants not a yellow flowered plant could be found.

Of considerable interest is the fact that the segregating progeny came from the cream flowered parent. The yellow colour was, therefore, partially dominant in this particular cross. In the $F_2$ progeny of this cross consisting of 150 plants, approximately 110 plants were either light or dark cream. This substantiates the fact of partial dominance as evidenced in the hybrid. The rest of the plants were pure white, creamy white, light yellow or yellow.

Both the $F_1$ hybrid and plants of the $F_2$ progeny set seed reasonably well, but whether or not they were fully fertile could not be determined with certainty. Young plants of the $F_2$ progeny were considerably less vigorous than normal plants and a majority of them had chloratic foliage in the early stages of the second season's growth, leaves of many plants being almost white. This condition persisted only for a time. In other respects the plants appeared to be quite normal.

Another part of this experiment in natural crossing, being exactly the reverse of that described above but much less extensive, was conducted at the same time. In this case seed was taken from a yellow flowered row of sweet clover surrounded by white flowered plants. This also was grown in an isolation plot, but owing to poor conditions for germination, only 205 plants grew. All were yellow flowered. Seed was selected from each of these and about 4,000 plants grown from a mixed sample. All of these proved to be yellow flowered. The results, therefore, contained no evidence of natural crossing.

## Discussion

The writer has long held the opinion that natural crossing between white flowered and yellow flowered sweet clover either does not occur or that it is of relatively rare occurrence. This view was based on experience during the past ten years during which time hundreds of strains from selected plants of the white and yellow flowered species have been grown in the same nursery, often side by side. Re-selections from these strains have been made at frequent intervals, especially in the white flowered species, but never has a single plant progeny been found to segregate for yellow and white flower colour. Moreover, in the production of registered seed of Arctic sweet clover, which is a white flowered variety, no difficulty traceable to natural crossing has been experienced in maintaining purity, with respect

to colour of blossoms. The same may be said with reference to the purity of other white flowered varieties.

The fact that a cross between white flowered and yellow flowered sweet clover has never been reported also bears evidence to the rarity of natural crossing between these species. The $F_1$ plant and the $F_2$ progeny described above gave cream coloured flowers for the heterozygous condition. If this should prove to be the rule, such hybrids would be easily detected, but the writer has never before observed a sweet clover plant with cream coloured flowers other than those described above.

The conditions for natural crossing in this experiment were ideal. White flowered plants flanked for 30 feet on either side with yellow flowered plants of different types and varieties, fine weather during the time of blossoming and great numbers of honey bees, all favored the distribution of pollen. Conditions were natural and not artificial, as is frequently the case in studies of this kind. Less than one-hundredth of one percent of natural crossing occurred. If this is a typical result under optimum conditions, how much less may natural crossing be expected to occur under normal conditions in the growing of field crops. These data will be of considerable interest to members of the Canadian Seed Growers' Association, which is at present formulating standard regulations for the production of pure seed of the open-pollinated crops.

There is a remote possibility that the honey bee is not effective as an agent for cross-pollinating sweet clover in which case the absence of natural crossing might be attributed to the absence of suitable insects. This circumstance in itself, of course, would not militate against the results of the experiment for the condition under which it was made. However, the likelihood that honey bees do not effect cross-pollination need hardly be considered, since it is well known that they are the most frequent visitors to sweet clover flowers. In their "Pollination Studies of Seed Production", Coe and Martin state that, "In the United States, the honey bee is the most important pollinator of sweet clover." In view of these facts, it is hardly reasonable to assume that honey bees, which are so partial to sweet clover flowers, may not be important in cross-pollination, although such a circumstance is not imposible.

## Summary

1. An experiment to determine the degree of natural crossing between white flowered and yellow flowered sweet clover under optimum conditions for cross-pollination resulted in less than one-hundredth of one percent natural crossing.

2. A cross between white flowered and yellow flowered sweet clover is reported in which the $F_1$ hybrid possessed cream coloured flowers and the $F_2$ progeny, consisting of 150 plants, gave four shades of yellow in addition to pure white and pure yellow, the great majority being light or dark cream.

3. The data on natural crossing herein reported substantiate the theory that natural crossing between yellow and white flowered species of sweet clover is very rare.

4. Since natural crossing under the conditions of this experiment was so rare as to be negligible for all practical purposes, there is a strong probability that seed of white sweet clover may be produced in the same vicinity in which yellow sweet clover is growing without incurring appreciable risk of cross-pollination.

# CONTAMINATED WATER AS A SOURCE OF SURFACE FLAVOR IN PASTEURIZED CREAMERY BUTTER

DONALD BETHUNE SHUTT†
*Ontario Agricultural College, Guelph.*

[Received for publication November 13, 1928.]

Within the past ten years bad flavors have come to the attention of the butter graders. These flavors are characterized as sewage-like, unclean and putrefactive. Because the first traces of these flavors always appear on the surface of the butter the name surface flavor has been adopted.

The writer has been investigating outbreaks of this flavor for the past six years and during this period has noted the following significant facts:

1. No samples of surface flavor butter have ever been received from city creameries where the water supplies were known to be pure.
2. All samples of surface flavor butter have had their origin at rural creameries, or at city creameries where the water supplies have not been pure.
3. Practically all outbreaks of surface flavor followed periods of heavy rainfall.
4. Very few samples of surface flavor butter have been received during the winter months. The great majority have always come during the spring and summer.
5. Several samples of surface flavor butter appeared to be over neutralized.
6. Surface flavor has never been found in sour cream butter but always in sweet cream or neutralized butter.
7. Water supplies at all creameries investigated were found to be contaminated with large numbers of putrefactive bacteria, chief of which has been *Pseudomonas fluorescens.*

## INVESTIGATIONAL

With the above observations in mind samples of water were obtained from two creameries troubled with surface flavor in their butter. The water was analyzed by plating with Milk Powder Agar (Ayers and Mudge) of pH=6.8 reaction and incubated at 25°C. for four days. All alkali-forming bacteria were isolated in pure culture.

Transfers of each pure culture were made to sterile skim milk and incubated at 25°C. for four days. The cultures which produced putrefactive odors were retained.

Table 1 is the record of the action of these cultures in milk.

†Lecturer in Bacteriology.

TABLE 1.—*Showing the action in milk of eleven cultures of bacteria isolated from suspected water supplies.*

| Lab. No. | Color changes | Odor | Remarks |
|---|---|---|---|
| S 1. | Brownish yellow | putrefactive | |
| S 2. | No change | putrefactive | |
| S 3. | Brownish yellow | putrefactive | |
| S 4. | Brownish yellow | putrefactive | |
| S 5. | Greenish yellow | very putrefactive | |
| S 6. | Brownish yellow | putrefactive | |
| H 1. | No change | slight putrefactive | |
| H 2. | No change | slight putrefactive | |
| H 3. | No change | No change | |
| H 4. | | | Mixed culture. |
| H 5. | Greenish yellow | very putrefactive | |
| H 6. | Light brown | putrefactive | |
| Control | No change | no change | |

## EXPERIMENTS WITH BUTTER

Two pounds of special pasteurized unsalted butter were obtained from the College dairy. The butter was placed in glass containers and subjected to steam pressure of fifteen pounds for twenty minutes. It was then removed, mixed and poured into sterile deep culture dishes and allowed to cool. Care was taken to ensure uniformity by thorough agitation of solids and fat during the pouring. When the butter was hard each culture dish was inoculated with a different organism and one dish was kept as a control.

Inoculations were made by scraping the surface of each agar slant culture with a sterile platinum loop and transferring to sterile tubes containing five cubic centimeters of water. Care was taken to have each transfer as uniform as possible. The water and the bacteria were well mixed and each tube was poured into a separate culture dish. To ensure penetration a sterile butter iron was forced to the bottom of each dish. The control dish was subjected to the same measures except that five cubic centimeters of water without bacteria were added.

All the dishes were incubated together at 25°C. for twenty-eight days.

Mr. A. B. Clark of the Ontario Butter Grading Station very kindly graded all the dishes.

Table 2 is the record of the action of these cultures upon the butter.

TABLE 2.—*Showing the action in butter of eleven cultures of bacteria isolated from suspected water supplies.*

| Lab. No. | Odor | Flavor | Grade | Remarks |
|---|---|---|---|---|
| S 1. | putrefactive | putrefactive | off | slight surface flavor |
| S 2. | putrefactive | putrefactive | off | slight surface flavor |
| S 3. | putrefactive | putrefactive | off | slight surface flavor |
| S 4. | putrefactive | putrefactive | off | like rancid cheese |
| S 5. | putrefactive | putrefactive | off | typical surface flavor |
| S 6. | putrefactive | putrefactive | off | like rancid cheese |
| H 1. | slight putref. | slight putref. | 2 | no particular flavor |
| H 2. | slight putref. | slight putref. | 2 | no particular flavor |
| H 3. | putrefactive | putrefactive | 3 | flavor not identified |
| H 4. | | | | mixed culture |
| H 5. | putrefactive | putrefactive | off | typical surface flavor |
| H 6. | putrefactive | putrefactive | 3 | slight surface flavor |
| Control | no change | no change | special | |

Cultures of S5 and H5 both gave typical surface flavor and S1, S2, S3 and H6 gave traces of surface flavor. The control retained its original grade.

The cultures of S5 and H5 were then traced out and both were found to be pure cultures of *Pseudomonas fluorescens*.

### Method for Detecting *Pseudomonas fluorescens* in Water

Having produced surface flavor in butter under laboratory conditions the next step was to elaborate an easy method for the detection of these bacteria in suspected water supplies.

As beef extract agar is the most commonly used solid medium in the average laboratory, it was selected for experimentation. The formula as laid down in Standard Methods of Milk Analysis, 1927, calls for a final reaction of pH=6.6. *Pseudomonas fluorescens* will grow but feebly at pH=6.6. After testing out various degrees of hydrogen ion concentration, pH=7.2 was found to be the most satisfactory. Another slight change was necessary as the incubation temperature of 37°C. was found to be unsuitable. Incubation at 25°C. proved to be the most satisfactory temperature.

If water containing *Pseudomonas fluorescens* is plated in quantities of one cubic centimeter and one tenth cubic centimeter, the colonies of the bacteria will usually show up. The area surrounding the colonies will be coloured a yellowish green.

### Field Investigations and Control Methods

The water supplies at all creameries investigated for surface flavor were found to be contaminated with at least one hundred *Pseudomonas fluorescens* colonies per cubic centimeter. Creameries with the worst outbreaks had counts of over one thousand.

Three suggestions were made to control surface flavor development:

1. New deep wells were suggested for rural creameries not dependant on municipal water supplies.
2. Where municipal water supplies were involved, instructions were given to heat the water to 190°F. and to cool before washing the butter.
3. Where no immediate steps could be taken to remedy the contamination, the suggestion was made to neutralize the cream to .35% acid instead of .25% acid.

### History of Creameries Investigated

*Creamery A.* This creamery was troubled with surface flavor periodically. The manager suspected the water supply and boiled the wash water for a time, with satisfactory results.

Samples of the water supply were analyzed and found to be badly contaminated. A new well was bored and no futher surface flavor appeared.

*Creamery B.* This creamery was dependant upon a shallow well that was evidently fed from a nearby pond of stagnant water.

After a deep well had been bored and connected up the trouble stopped.

*Creamery C.* This creamery obtained its water from a shallow well beside a small stream. The surrounding land was polluted with seepage from a nearby privy and from hogs. With the sinking of a new well on clean ground the flavor of the butter improved immediately.

*Creamery D.* This creamery was dependant on the town water supply, which was found to be contaminated with *Pseudomonas fluorescens* but not from intestinal bacteria. The water was safe from a public health standpoint.

The suggestion was made to pasteurize and cool the wash water. It was finally found that the temperature of 190°F. for ten minutes was necessary, as 170°F. and 180°F. for ten minutes failed to destroy all the bacteria.

A marked improvement in the flavor followed this treatment.

*Creamery E.* This creamery had at one time been a cheese factory. The waste material had been allowed to pollute the surface of the surrounding land for many years. The original well was located at the rear of the creamery, and very close to it, and was but thirteen feet deep.

Surface flavor in the butter was the rule rather than the exception. Analysis of the water proved it to be grossly contaminated with *Pseudomonas fluorescens.*

Instructions were given to abandon the old shallow well and to sink a new one through the rock. Owing to the difficulty of obtaining another site for the well it was bored some three feet from the original. The depth of the new well was one hundred and eighty feet.

Following the construction of the new well surface flavor became more pronounced than ever in the butter. Analysis of the water proved it to be grossly contaminated.

Instructions were then given to chlorinate the old well and fill it up, as it was presumed that the water from the old well might have been seeping down the sides of the casing of the deep well. No improvement followed.

Samples of water were next taken from the bottom of the new well. These proved to be relatively free from pollution. Arrangements were then made to secure the water from the bottom of the well by inserting a pipe down and inside the larger casing.

Since this arrangement was completed surface flavor has disappeared from the butter.

Data of the numerous analyses of the water would indicate that the casing of the new well was cracked somewhere below the surface of the ground and probably in the first fifteen feet.

After the new well was completed and during the period that was necessary to obtain pure water from the lower levels, the manager was instructed to neutralize all the cream to .35% acid instead of the usual .25%. The writer based these suggestions on various laboratory experiments which indicated that the presence of acid would inhibit the growth of *Pseudomonas fluorescens.* Satisfactory improvements were noted in the flavor of the butter while this procedure was in force, but the method is not to be recommended as a permanent means of control, owing to the chance of error.

Surface flavor developed in the butter of several other creameries following a prolonged period of very rainy weather, but disappeared immediate-

ly fine weather set in. The water supplies of each creamery were examined and found to be contaminated, but as the contamination quickly disappeared and the flavor of the butter improved with the coming of the fine weather, no action was taken.

## Summary

Surface flavor butter is almost unknown in city creameries, where the water supplies are known to be pure, but it would appear that this flavor is quite prevalent in creameries in the rural districts, especially after prolonged periods of wet weather.

All suspected water supplies were found to be contaminated with *Pseudomonas fluorescens.*

Sterile butter when inoculated with this organism and incubated at 25°C. for twenty-eight days developed typical surface flavor.

Investigations in the field and laboratory proved that this flavor could be controlled by:

1. Substitution of pure water for contaminated water for butter washing.
2. Subjecting contaminated water to a temperature of 190°F. for ten minutes.
3. Neutralizing the cream to not less than .35% acid.

# LE FACTEUR CLIMAT DANS LA GENESE ET LA CLASSIFICATION DES SOLS*

H. M. Nagant
*Institut Agricole d'Oka, La Trappe, P.Q.*

Durant le premier Congrès international de la Science du sol, tenu à Washington au mois de juin de l'an dernier, il a été beaucoup question de "profils de sols", surtout dans les travaux et discussions de la "Cinquième commission", chargée spécialement des problèmes de nomenclature, classification et cartographie des sols. A l'exposition de matériel employé dans les études pédologiques, organisée à la même occasion dans les locaux de l'édifice de la Chambre de commerce des Etats-Unis, où se tenaient les séances du congrès, on put contempler une collection assez considérable de profils originaux, c'est-à-dire de monolithes taillés verticalement dans des sols en place, sur une profondeur de six à huit pieds et davantage.

A part un certain nombre provenant de quelques stations expérimentales des Etats-Unis, ces monolithes avaient presque tous été apportés par la délégation des savants russes au Congrès.

Un des principaux objectifs du voyage d'étude de plus d'un mois à travers les grandes régions physiographiques de l'Amérique du Nord, qui fit suite au Congrès proprement dit, fut encore l'examen de centaines de profils de sols.

Ceux-ci furent observés parfois à la faveur de sections faites récemment pour l'établissement de routes nouvelles ou de chemins de fer, mais le plus souvent dans de profondes tranchées creusées exprès aux endroits d'arrêts fixés par le programme.

Aussi, le terme *soil profile* ne tarda pas à devenir un *leit-motiv* presque obsédant et une mine inépuisable de jeux de mots et de facéties pour la partie humoristique du *"Boden Bull"*, journal de bord publié chaque soir sur le train d'excursion, dans le but de commenter les faits du jour, de donner les indications relatives au programme du lendemain et de conserver la bonne humeur et l'entrain parmi cet assemblage cosmopolite des fervents de la terre.

Les mots *podsol, terra-rossa, tschernosem* typique ou dégradé, *rendzina, solonetz,* etc., employés en relation avec la notion de profil, presque inconnus encore de la plupart d'entre nous autres il y a quelques années, revenaient à tout bout de champ dans les vives discussions engagées entre experts qui, sans autres armes à la main qu'une truelle et parfois un flacon d'acide chlorhydrique, avaient pris d'assaut la tranchée ou le talus pour en conquérir les horizons.

Tout ceci démontre bien l'évolution récente à laquelle nous assistons en matière de classification des sols et, notamment, l'influence considérable exercée par les conceptions de l'école agrogéologique russe depuis qu'elles ont pénétré dans la littérature scientifique de l'Europe Occidentale et de l'Amérique du Nord.

*Texte de la conférence faite, le 11 Juin 1928, à la Salle des promotions de l'Université Laval, au cours de la Convention annuelle de la Société des Agronomes Canadiens.

Comme le fait remarquer le Dr. C. F. Marbut, chef de la *Division of Soil Survey of the U.S. Bureau of Soils,* dans la préface de sa traduction de l'ouvrage de l'éminent pédologue russe, le docteur K. P. Glinka, ayant comme titre *"The great Soil Groups of the world",* parue il y a quelques mois seulement, l'immense domaine de la pédologie russe était à peu près entièrement inexploré jusqu'ici par les hommes de science en Amérique, dont presque aucun n'est capable de comprendre le russe à la lecture. L'ouvrage de Glinka, qui constitue un résumé de l'oeuvre pédologique russe, parut en 1914, mais la guerre empêcha pendant de longues années sa diffusion et ce ne fut qu'après avoir été traduit en allemand, d'abord, qu'il put être transposé en anglais ensuite. (*1*).

Ce que l'on vient de dire des rapports entre les travaux scientifiques russes en matière de sol, et les techniciens américains s'applique encore davantage aux relations de ces mêmes travaux avec la science agronomique francaise. Jusqu'en ces derniers temps, on n'y découvrait pour ainsi dire aucune trace des conceptions et de l'école agrogéologique si active dans l'Est de l'Europe depuis nombre d'années déjà.

Aussi peut-on dire que les points de vue auxquels se sont placés les pédologues russes dans l'étude de la genèse des sols et de leur classification ont été en quelque sorte une révélation pour nous.

Il est évident que l'on peut définir et classifier les sols de vingt manières différentes suivant le point de vue que l'on adopte, mais il est une définition sur laquelle tous les géologues et pédologues contemporains peuvent facilement se mettre d'accord, et qui est la suivante:

"Le sol est la partie superficielle de la lithosphère exposée aux dégradations des agents atmosphériques et biologiques."

Il ne forme donc qu'une phase dans le cycle des transformations continuelles que subissent les constituants de la lithosphère, et qu'en géologie on appelle métamorphisme, ce terme étant compris dans sa signification la plus générale. Cette phase est faite des réactions mutuelles entre les minéraux de la lithosphère, les constituants de l'atmosphère, les organismes de la biosphère et les déchets de ces derniers.

D'après cette définition très générale, le sol se confond aussi avec la zône de catamorphisme ou de métamorphisme destructif que nous décrit le géologue américain Van Hise, dans le schéma si clair et si ingénieux imaginé par lui pour représenter les trois zones successives de métamorphisme rencontrées lorsqu'on pénètre verticalement dans l'écorce terrestre, de la surface à l'intérieur, à savoir:

1—*La zone de fracture,* qui s'étend depuis la surface jusqu'au niveau de la nappe aquifère et est accessible en tous sens aux agents atmosphériques et biologiques, ou s'opère la dégradation ou simplification des minéraux et des roches.

2—*La zone de cimentation,* région fissurée et poreuse, constamment gorgée d'eau, qui s'étend en profondeur jusqu'à.

3—*La zone de plasticité,* niveau auquel la disparition de toute fissure ou pore, sous l'influence des pressions énormes qui y règnent, empêche l'eau sollicitée par la gravitation de descendre davantage. (*2*).

Par cette définition, on voit qu'il y a trois grands facteurs à considérer dans la genèse du sol.

1—Le facteur géologique ou pétrographique, dont dépend la nature de la matière fournie sous forme d'espèces minérales originelles.

2—Le facteur atmosphérique, qui intervient par les constituants de l'air: eau de précipitation, oxygène, anhydride carbonique, azote et la température variable de deux-ci.

3—Le facteur biologique, agissant par le métabolisme des organismes vivants et leurs produits de décomposition ou déchets.

On pourrait faire remarquer cependant que le troisième facteur n'est lui-même que fonction de l'action combinée des deux autres, qui, en fin de compte, sont seuls à retenir comme facteurs premiers.

Par contre, il y a lieu parfois de tenir compte, ainsi qu'on le verra, de certains facteurs qui peuvent devenir prépondérants dans des cas particuliers de développement d'un sol. Tels sont la topographie et l'eau souterraine.

Lorsqu'on passe en revue toute la partie de la littérature scientifique des pays occidentaux de l'Europe tels que la France, la Grande-Bretagne, l'Allemagne, qui s'occupe des sols, il est aisé de constater que c'est presque exclusivement le facteur géologique qui est entré en ligne de compte dans les systèmes de classification.

Les savants qui dans ces pays ont abordé l'étude des sols d'un point de vue scientifique étaient surtout des géologues et les ont considérés comme de simples roches ou associations de minéraux divers, à l'état statique. Aussi les ont ils le plus souvent classifiés d'après les espèces minérales prédominantes qui ont servi de matière première.

C'est ainsi que dans les traités et manuels français d'agronomie, on trouve constamment les sols d'une région désignés sous des qualificatifs tels que: *granitique*, ce qui implique une terre pauvre en chaux et riche en potasse, d'une composition analogue à la roche éruptive dont il dérive; de *Marne Lyasique,* pour indiquer un sol formé sur un calcaire friable du Lyas; de *limon des plateaux,* ce qui l'identifie avec le loëss recouvrant certaines régions sur une épaisseur parfois considérable.

Une autorité telle que Risler, dans son "Traité de Géologie Agricole" (en 4 volumes, 1885), affirme que la meilleure carte des sols est la carte géologique détaillée, exécutée à grande échelle, telle, par exemple, la carte éditée par le Service géologique de France. Il identifie donc les sols avec les formations géologiques sur lesquelles ils se sont formés.

Ces cartes géologiques, suivant Risler, "doivent devenir la base des travaux des chimistes et des ingénieurs agronomes comme des ingénieurs forestiers, qui auront à faire l'aménagement rationnel des matières minérales de la France.

"Risler eut une influence énorme sur les études ultérieures et surtout sur la description des sols de la France. Cette description est devenue entièrement géologique et est prise comme base de toutes les cartes agronomiques des différentes communes et cantons qu'on publiait en grand nombre avant 1900". (*3*).

Le professeur P. Waguet, de l'Institut Agronomique de Beauvais, dans un travail présenté à la Deuxième commission de la "Conférence internationale de pédologie," réunie à Rome, en mai 1924, montre pourquoi on doit considérer la terre arable comme un véritable objet d'étude géologique, ce qui démontre encore une fois la préoccupation uniquement géologique dans la manière d'envisager le sol. (*4*).

Est-ce à dire maintenant que les agrogéologues de France et d'autres pays de l'Europe Occidentale, en étudiant le sol, ont ignoré ou négligé les transformations multiples et complexes que subit la roche mère sous l'influence conjointe des agents atmosphériques et biologiques, dans le processus de formation?

Non, évidemment, nous savons bien que ces sujets sont traités assez longuement dans tous les ouvrages s'occupant du sol d'une manière scientifique. Des chapitres entiers parfois nous décrivent le dégradation des silicates au moyen des trois modes d'action chimique mis en oeuvre par les agents atmosphériques: hydratation, carbonatation et oxydation. Les produits de décomposition des matières organiques, quoique très mal connus encore, et leurs actions réciproques sur les minéraux générateurs du sol sont également étudiés.

Mais tout cela est considéré comme si ces agents atmosphériques et biologiques opéraient partout et toujours d'une façon identique sous des conditions climatériques uniformes, correspondant à celles d'un climat tempéré et humide, qui prévalent dans l'Europe occidentale comme dans l'Est des Etats-Unis; ce qui laisse supposer qu'une même espèce de roche génératrice donnera partout des sols identiques.

Pour l'agrogéologue français, des deux facteurs premiers qui interviennent dans la genèse du sol, origine géologique ou roche mère et climat (agents atmosphériques et température), le second est donc considéré comme une constante, tandis que le premier apparaît d'autant plus variable que les formations géologiques sont, ainsi qu'on le soit, extrêmement variées en France et en Angleterre.

Dans ces conditions, on comprend assez facilement cette tendance générale des agronomes de France et d'autres pays où les différences de climat sont relativement peu marquées, à classifier les sols d'après le facteur fondamental qui est sujet aux plus grands changements. Nous pourrions les comparer un peu au meunier qui s'imaginerait de classifier les pains en supposant que la pâte se pétrit et se cuit toujours de la même façon. Ne serait-il pas assez naturel qu'il songeat avant tout à les classifier d'après le genre de céréales servant de matière première, dont il a chaque jour l'occasion d'observer la diversité.

Il en fut tout autrement de l'école agrogéologique russe dont Dokoutchaiev fut le fondateur, il y a un demi-siècle environ, et Sibirtzev et Glinka les plus éminents parmi les nombreux continuateurs et disciples. Notons que les études entreprises en Russie par Dokutchaiev et ses disciples furent défrayées par certains gouvernements provinciaux ou *zemstvos,* tels que ceux de Poltava et Nigninovgorod; l'objectif des *zemstvos* était surtout d'établir des bases scientifiques précises pour l'évaluation des terres, en vue de leur imposition. C'est ainsi que furent éditées des cartes pédologiques de

différents districts de la Russie, accompagnées de statistiques détaillées concernant les divers types de sol et leur productivité. (*3*).

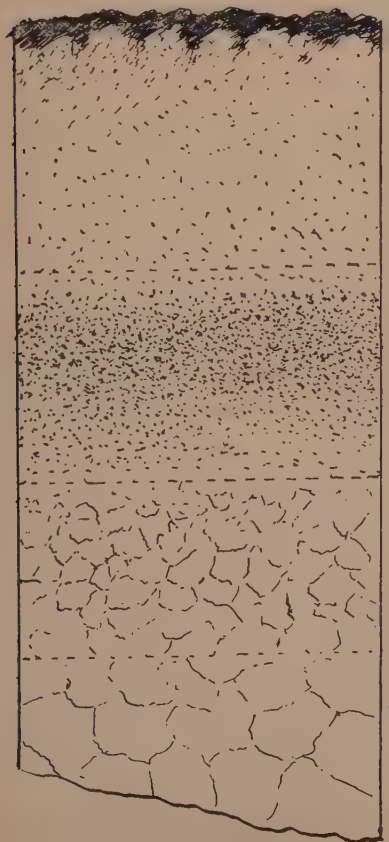
Opérant dans un immense empire étalé à travers des zones climatériques très différentes, aussi bien au point de vue la température que des quantités de précipitions atmosphériques, ces investigateurs avaient observé, ainsi que d'autres pédologues le firent, d'ailleurs, aussi, que tous les sols normalement développés présentaient, sur une coupe verticale d'un certain nombre de pieds de hauteur, trois couches ou horizons successifs, plus ou moins nettement marqués par la teinte, la texture, la structure et la composition, à savoir:

1—Un horizon superficiel, désigné actuellement par la lettre A, d'où certains produits de décomposition des constituants minéraux et organiques ont une tendance à être délavés à l'état de solutions vraies ou de pseudo-dissolutions colloïdales. On a encore donné à cette couche le nom *d'horizon éluvial.*

2—Immédiatement en dessous vient une zone indiquée par la lettre B, appelée *horizon illuvial* parce que les matériaux entrainés de l'horizon A ont une tendance à s'y déposer sous forme de sels divers (principalement des carbonates) et de *gels* ou colloides floculés.

3—Plus bas, nous aurons l'horizon C, constitué d'une couche de roche mère dont les matériaux originaux sont peu modifiés.

4—Enfin, de l'horizon C on passe à la roche génératrice non différenciée, parfois indiquée par la lettre D.



Mais ce qui frappa en particulier les savants russes dans leurs observations de coupes ou profils de sols, au cours de leurs expéditions d'une extrémité de l'empire moscovite à l'autre, ce furent les grandes variations dans les composition, teinte, texture, structure et épaisseur de ces horizons respectifs suivant les conditions climatériques, alors même que les sols étudiés provenaient de roches mères identiques.

De la l'importance primordiale qu'ils ne manquèrent pas d'accorder au climat dans la genèse des sols et son adoption comme base principale de classification. Poussant même leurs travaux en dehors de la Russie, les pédologues slaves étudièrent l'action différentielle du climat dans des pays soumis à des conditions plus différentes encore, tels que les régions tropicales, et établirent ainsi un système général de classification, s'appliquant au monde entier, dont les données se trouvent résumées dans l'ouvrage de Glinka, qui vient d'être traduit en anglais par le Dr. Marbut, ainsi qu'on l'a dit plus haut.

Persévérant dans cette petite manie, nous pourrions comparer le point de vue russe en matière de classification des sols, à celui qu'adopterait le boulanger chargé de la même tâche pour les pains. Ayant eu, mieux que le meunier, l'occasion d'observer qu'une même farine peut donner des pains très différents suivant la manière de pétrir et de cuire la pâte, il y à gager dix contre un qu'il adoptera comme facteur principal de classification les agents qui interviennent dans la transformation de la farine.

Les discussions soulevées autour des facteurs de classification amenèrent la Conférence internationale agrogéologique de Stockholm, tenue en 1910, à nommer un comité spécial de nomenclature et de classification, auquel fut assignée la tâche de résoudre le problème pour les pays du Nord de l'Europe.

Interrompus par la guerre mondiale, les travaux de ce comité furent repris activement dans la suite et firent l'objet d'un recueil de mémoires publié sous la direction de son président, le Dr. Benjamin Frostérus, de Helsingfors (Finlande), en 1924.

Avec quelques variantes, les experts des pays de l'Est de l'Europe (Pologne, Finlande, Allemagne, Danemark, Hongrie, Roumanie) adoptèrent les idées générales développées par l'école russe et la terminologie qu'elle emploie dans la description des profils de sols.

Ce fut encore cette même terminologie qui devint courante dans l'examen des sols pendant la grande excursion agrogéologique organisée par le Congrès de Washington et qui est employée aujourd'hui par les spécialistes en choses du sol aux Etats-Unis.

Pour avoir un aperçu de la nomenclature nouvelle et démontrer tout l'intérêt que présente le facteur climat qu'elle comporte, nous donnerons une brève description de quelques profils respectivement typiques pour des zones climatériques bien tranchées, tout en nous arrêtant un peu plus longuement à ceux correspondent aux conditions tempérées et humides de l'Est du Canada.

En commençant par les régions désertiques arides, qui unissent à des précipitations atmosphériques extrêmement faibles une température moyenne élevée, nous aurons:

Des sols salins, dont nous ne dirons rien si ce n'est qu'ils présentent des profils très peu développés, en raison de la faible altération de la roche

mère, de l'absence presque complète de matière organique et du déplacement insignifiant des produits de décomposition des minéraux générateurs.

Passant de là aux districts semi-arides seulement, on aura surtout des sols alcalins, comme dans la Californie, l'Utah etc.

Les sols alcalins peuvent se subdiviser en deux types suivant que la matière saline dominante sera du $Na_2CO_3$ ou bien du NaCl et du $Na_2SO_4$, d'après Glinka.

Dans la première hypothèse on aura un *solonetz,* caractérisé par une structure particulière des horizons due à l'action du $Na_2CO_3$. Ce sel qui se forme dans l'horizon A est entraîné dans l'horizon B pendant les périodes d'humidité et y détermine le défloculation des colloides, le rendant plastique et imperméable ; mais au cours des périodes de sécheresse le $Na_2CO_3$ remonte vers la surface, et l'horizon B prend une structure en forme de piliers prismatiques (structure colonnaire) par suite du retrait que détermine le desséchement.

Si on a surtout affaire à du NaCl et du $Na_2SO_4$ il se formera un profiil de *solonschak,* lequel se distingue par une absence de structure spéciale des horizons. Les ions positifs des électrolytes maintiennent les colloides humiques et minéraux à l'état coagulé ; ils ne sont donc pas entraînés dans les horizons sousjacents et la structure est uniforme dans les différents horizons (*1*).

Observons que Hilgard, ce pionnier de la Science des sols en Amérique, avait déjà fort bien étudié les sols alcalins, qu'il pouvait observer en Californie.

### Le Profil du Tschernosem, ou de la Terre Noire des Steppes Herbeuses ou Prairies

Est typique pour les étendues recevant des précipitations atmosphériques modérées, mais déjà plus fortes que celles des sols alcalins, et dont la température peut varier entre le tempéré chaud et froid. Sous de telles conditions, il se développe une abondante végétation herbacée, à l'exclusion de la forêt, phénomène qui est encore imparfaitement expliqué, d'ailleurs, et qui a donné lieu à l'expression d'un grand nombre d'opinions.

La décomposition de la matière organique produite par les graminées procède lentement, l'humus formé est peu mobile. D'après le Dr. Peter Treitz, les composés humiques colloidaux commencement à être lessivés de la couche de litière superficielle, sous l'influence de l'eau contenant en dissolution le $(NH_4)\ 2\ CO_3$ qui s'y forme, mais ils sont bientôt floculés et saturés par le Ca dans les couches inférieures (*5*).

L'immobilisation de l'humus empêche aussi la descente des matières limoneuses dans les couches sous-jacentes.

Les sels alcalins et alcalino-terreux provenant de la dégradation des minéraux, de la roche mère sont incomplètement lessivés ; les moins solubles, tels que $CaCO_3$ et $CaSO_4$ se déposent bientôt. L'altération des aluminosilicates est peu intense et, selon Glinka, n'aboutirait qu'à la formation de sels faiblement acides, sans arriver au terme d'argile.

Aarnio et Stremme font remarquer que le tschernosem dans la forme la plus parfaite possède un équilibre des matières minérales.

Dans les horizons supérieurs il n'y a ni délavage ni enrichissement en produits minéraux de dégradation, seul l'humus, qui est complètement coagulé et presque insoluble, s'accumule en quantités plus ou moins considérables dans les couches supérieures.

Le professeur russe Vilensky, de l'Université de Kharkoff, auteur d'une classification des sols par séries analogues de formation, dans lesquelles chaque type de sol ne représente qu'une phase d'un cycle complet d'évolution, affirme que c'est à la phase du *tschernosem* qu'un sol a atteint le point culminant de toutes ses propriétés, de sa puissance et de sa productivité. Après cela commence la période de décrépitude et d'acheminement vers la mort (*6*).

Lorsque la végétation forestière parvient à s'implanter dans le sol des prairies, (remarquons que l'on n'est pas d'acord pour attribuer ce fait à une augmentation de la quantité d'eau annuelle tombée) les conditions d'évolution du sol changent.

Sous le couvert des arbres, l'atmosphère demeure plus humide, de même que les couches superficielles du sol, quoique la végétation ligneuse épuise davantage l'eau du sous-sol et abaisse le niveau de la nappe aquifère.

Une température plus uniforme et une humidité plus constante favorisent la décomposition de la matière organique, dont les produits de dégradation sont, d'ailleurs, de nature différente de ceux qui prennent naissance sous le régime des steppes herbeuses. L'équilibre entre l'accumulation et la destruction de la matière organique existant sous ce dernier régime est rompu; l'humus ancien, formé durant la phase de la steppe, de même que celui provenant des déchets de la forêt se décompose, le *Ca* absorbé est délavé, les humates deviennent mobiles et sont entrainés par la solution du sol dans les profondeurs (*1*).

Avec la décomposition de la matière organique son influence protectrice et conservatrice disparait pour faire place à un processus de désagrégation beaucoup plus énergique de la matière minérale du sol. Les oxydes colloidaux sont entraînés à une profondeur beaucoup plus grande et, en fin de compte, il ne reste plus dans l'horizon A que du quartz et des silicates inertes.

Nous assistons à la dégradation complète du *tschernosem,* dont le terme est la phase du *podsol,* c'est-à-dire du sol cendreux pauvre, chez qui la forêt s'est substituée à l'abondante végétation herbacée de la prairie. Aussi Vilensky considère l'invasion des végétaux ligneux comme le commencement de la décrépitude pour la phase du *tschernosem.*

Au tschernosem du centre de la Russie doivent donc se rapporter les terres noires ou prairies des grandes plaines de l'Ouest des Etats-Unis et du Canada que les pédologues russes ont pu voir à l'état typique ou plus ou moins dégradé et comparer pour la première fois avec les profils de chez eux, pendant le voyage du Congrès International.

Pas n'est besoin de faire remarquer que la prodigieuse production de blé de ces terres de l'Ouest, appelées à juste titre les greniers du monde, est bien l'indice de ce point culminant atteint à la phase du *tschernosem.*

Des conditions climatériques humides, pouvant varier entre le moyennement humide et le très humide, donneront lieu à la formation de deux types de sols extrêmes, suivant qu'elles sont accompagnées d'une chaleur tropicale ou des basses températures qui règnent aux abords des cercles polaires.

Dans la premier cas, il y aura développement de latérites ou sols latéritiques, et dans le deuxième de toundras. Entre les deux, c'est-à-dire pour une température oscillant entre le tempéré froid et le tempéré chaud, on verra apparaître un profil de sol qui doit intéresser plus particulièrement les agronomes de l'Ontario, du Québec et des Provinces Maritimes, parce qu'il est propre à ces régions, le profil des sols podsolés, qui est réalisé de la manière la plus parfaite chez les sols dont l'horizon $A_2$ prend une teinte d'un gris blanchatre, comme la cendre de bois, d'où lui vient le nom russe.

## Laterites

Quoique nous n'ayons évidemment pas l'occasion d'observer des sols latéritiques au Canada, nous en dirons cependant quelques mots en raison de leur constitution curieuse qui démontre bien la différence considérable qu'il peut y avoir entre les produits de dégradation d'une même roche mère, selon le degré de température qui y préside.

Dans les régions tropicales humides, nous dit Glinka, la décomposition des matières organiques est très intense et l'altération des silicates est poussée à l'extrême. Non seulement les bases alcalines et alcalino-terreuses sont énergiquement lessivées, de sorte que les composés humiques colloidaux non saturés sont rapidement entraînés à l'état de *sol,* mais l'hydrolyse dépasse le terme d'argile, que nous sommes habitués à considérer comme final sous notre climat tempéré, la silice elle-même se sépare du silicate et est entraînée ne laissant comme résidu insoluble que de l'alumine et des sesquioxydes de fer hydratés, avec accessoirement, des oxydes de manganèse et de titane. Le tout forme alors un horizon de structure vacuolaire, d'une teinte rouge brique, caractéristique, dans lequel c'est tantôt l'alumine, tantôt le sesquioxyde de fer qui domine, suivant l'abondance relative des silicoaluminates ou des silicates ferromagnésiens et autres minéraux ferrifères dans la roche mère.

Le géologue français A. Lacroix, nous donne un tableau d'analyse d'un certain nombre d'échantillons de latérites prélevés en Guinée, dont quelques chiffres sont absolument frappants.

C'est ainsi qu'on y voit des spécimens dosant jusqu'à 60.19% de $Al_2O_3$, lorsque séchés à l'air seulement, et 88.52% de la matière minérale anhydre.

En réalité, les latérites alumineuses représentent de véritables minerais d'aluminium, et les gisements de bauxite, activement exploités dans certains pays soumis encore actuellement à un climat tropical, pour alimenter les fabriques d'aluminium de la province de Québec, ne sont que d'anciens sols latéritiques fossilisés. Le professeur Stremme fait remarquer qu'on retrouve des profils complets de latérites, avec tous leurs horizons, dans certains gisements de beauxite.

Par contre, les variétés de latérites ferrifères sont parfois employées comme minerai de fer en Afrique (*1*).

## Toundras

Nous ne nous arrêterons pas aux sols des *toundras,* qui sont spéciaux à la zone froide dont font partie les territoires du nord du Canada, Ungava, Keewatin, etc. Ils n'offrent guère d'intérêt pour l'agronome pratique.

Le facteur prédominant dans le développement de ces sols est l'eau, et le processus général est analogue à celui observé pour les sols tourbeux des marais qui sont des types intrazonaux.

L'eau et le $CO_2$ y produisent une action hydrolytique énergique sur les silicates. Les conditions anaérobies entraînent la formation des produits ordinaires de réduction FeS—$FeS_2$—$FeCO_3$, phosphate ferreux hydraté (vivianite).

La décomposition des matières organiques s'effectue lentement, et, contrairement à ce que l'on pense, celles-ci seraient le plus souvent à réaction alcaline par suite de la présence de carbonates alcalins issus de la dégradation des silicates (*6*).

### Profils Podsoles

Les profils de podsol sont ceux qui se développent dans les régions humides dont l'air est habituellement humide et où les solutions du sol se déplacent en ordre principal de haut en bas (*7*).

Glinka pense que la genèse des podsols est en relation intime avec l'état boisé, parce que la plupart du temps ces sols représentent une des caractéristiques propres aux régions forestières.

Le même auteur observe cependant qu'on connaît des exemples de développement de podsols en dehors de l'influence de la végétation forestière.

Déjà en 1836, Kindler (*Kindler Boggend Ann.*) attirait l'attention sur l'état de décoloration des sables en-dessous des peuplements de conifères. Daubrée, géologue français, mentionne le même phénomène observé en Lorraine et dans la plaine du Rhin.

C'est aussi à cause de la teinte cendrée de l'horizon de délavage de ces sols que le peuple russe lui donna, depuis les temps les plus reculés, le nom de *podsol,* qui veut dire terre semblable à la cendre, dérivé du mot russe *solo,* signifiant cendre.

Dans un profil de podsol normal on observe, en-dessous de la couche humifère de la surface ou horizon $A^1$, une zone décolorée marquée $A^2$, à laquelle fait suite l'horizon d'enrichissement ou illuvial B, généralement couleur de rouille, qui plus bas passe au sous-sol neu modifié ou horizon C. (*B. Frostérus*).

De là encore le nom de terres rouillées ou *Rosterden,* donné aux podsols en pays germaniques. La couche décolorée se voit surtout avec beaucoup de netteté dans les terres sablonneuses.

### Evolution du Podsol

Chez les podsols la décomposition des matières organiques est moins active que dans les latérites. L'humus peut s'y accumuler en quantités assez considérables, mais n'étant pas saturé par des bases, il passe facilement à l'état *d'hydrosols* (solution colloidale) qui agissent comme colloides préservatifs vis-à-vis des colloides minéraux, tels que les silicates d'alumine, oxydes ferriques et oxydes de manganèse hydratés et facilitent leur entrainement. En se coagulant simultanément dans l'horizon B, ces différents colloides le rendent plus compact et donnent fréquemment lieu à la formation d'une couche *d'alios, Ortstein* ou *hardpan.* (G. D. Glinka).

Dans ces conditions, les couches supérieures, horizon A, acquièrent une texture plus grossière et s'enrichissent en $SiO_2$, tandis que les niveaux sous-jacents, horizon B, et éventuellement C, où se déposent les matières entraînées deviennent plastiques et compacts (*1*).

La dégradation des silicates s'arrête au terme de silicates alumineux acides.

L'énergie avec laquelle procède la podsolisation dépend de plusieurs circonstances, telles que, par exemple, le relief du terrain, le degré d'humidité, la nature de la végétation et de la roche-mère. ,

Et, à ce propos, Glinka insistait sur le fait qu'un podsol peut se développer aux dépens de n'importe quelle roche, que ce soit un granite, une diorite ou un gabbro, parmi les roches éruptives; un schiste, un grés, ou un calcaire, parmi les roches sédimentaires; une argile à blocaux ou alluvionnaire, un sable ou une marne, s'il s'agit de roches non consolidées. Mais il est clair que le podsol variera avec la nature de la roche mère, et que son développement ne sera pas le même.

Ainsi un sable, qui dès l'origine déjà est pauvre en matériaux susceptibles de fournir des électrolytes à la solution du sol, sera rapidement et facilement podsolisé et donnera des horizons bien distincts. Les roches carbonatées, telles que les calcaires et les marnes, au contraire, retardent beaucoup le processus de podsolisation puisqu'elles fournissent continuellement à la solution du sol, des sels de calcium favorisant la coagulation sur place des colloides minéraux ou organiques qui prennent naissance (*8*).

Les marnes et les calcaires friables passent même par un autre type; celui du *Rendzina* (terme polonais) avant de devenir podsol.

A la phase de *rendzina*, les matières humiques coagulées par les sels de calcium sont difficilement solubles dans l'eau et restent accumulées dans l'horizon A. Il en sera de même des silicates alumineux colloidaux qui demeurent à état d'impuretés résiduelles du calcaire.

Les oxydes ferriques, par contre, seront partiellement réduits à l'état ferreux et descendront dans l'horizon B, en-dessous de la couche humifère, où ils repasseront à l'état ferrique, communiquant à cette couche une teinte brune, mais conservant une structure granuleuse et ne contenant pas de matière organique, ce en quoi elle diffère donc essentiellement de l'horizon à *Ortstein* ou *hardpan* des sols podsolés.

Toutefois la formation d'humus entraîne aussi le délavage énergique du $CaCO_3$, favorisé par le $CO_2$ que rejettent les microörganismes qui travaillent à l'humification, et à la longue le $CaCO_3$ finit par disparaître de même que le *Ca* retenu par les composés humiques; le sol devient acide, l'humus et les colloides minéraux sont rendus mobiles et descendent de l'horizon A dans l'horizon B, où ils s'accumulent pour former un *alios* ou *hardpan* acide.

Ainsi nous passons de la phase du *rendzina dégradé* à celle du *podsol*, qui se caractérise encore par la modification générale de texture et de structure des horizons A et B, le premier devenant plus grossier, le second s'enrichissant en particules fines devient plus compact.

Observons que le type du *rendzina* se place en marge de la classification climatérique; Sibirtzew le range parmi les sols intrazonaux, c'est-à-dire pouvant se présenter par surfaces isolées dans des zones climatériques différentes, parce qu'un facteur spécial, la nature de la roche mère, devient ici absolument dominant sur le facteur climat.

Il peut arriver parfois qu'à la phase du podsol succède celle du sol tourbeux; ceci se produit lorsque l'horizon B devient tellement imperméable par suite de l'accumulation des colloides que l'eau reste stagnante dans l'horizon A.

Le bureau d'évaluation des terres de la république de Lettonie a publié, sous la signature de J. Wityn, une brochure dont le traduction anglaise porte le titre de: *"A brief survey of soil investigations in Latvia"*. Ce travail fut présenté au Congrès international de la Science du Sol à Washington.

Il donne des exemples très intéressants des stades d'évolution d'un podsol sur des roches mères de composition variable. C'est ainsi qu'il nous décrit les profils successifs observés pour des substratums: 1° de gravier calcaire; 2° d'argile marneuse; 3° d'argile à blocaux calcaire et 4° de sable des rivages et des dunes (*9*).

Ces exemples sont fort suggestifs pour servir de comparaison dans des observations à faire dans un pays comme la province de Québec qui possède un climat très semblable à celui de la Lettonie, et où les podsols se développent sur des dépots morainiques et des alluvions post-glaciaires ayant aussi beaucoup d'analogie avec ceux de la république Baltique.

Aussi est il intéressant d'examiner les profils coloriés accompagnant la brochure de Wityn, pour illustrer les phases d'évolution de profils typiques de podsols tels qu'on en rencontre dans la province de Québec.

Les types de sols dont nous venons de donner très succintement la morphologie sont nettement tranchés et correspondent chacun à une zone climatérique bien distincte, telle que la zone tropicale humide et la zone tempérée humide.

Entre eux on trouve évidemment un assez grand nombre de types intermédiaires qui marquent les transitions graduelles d'une zone de climat à l'autre.

Ainsi, lorsque de Québec nous parcourons le versant Atlantique du continent américain, du nord au sud, nous rencontrerons des sols se rattachant plus ou moins nettement au type podsol, jusqu'à la latitude de Washington. Mais ce qui nous frappe en continuant toujours vers le sud, c'est qu'à mesure que les hommes noirs se font plus nombreux, les terres deviennent plus rouges. Aussi à partir de la Caroline du Nord jusqu'en Géorgie, les participants de l'excursion du Congrès international de la Science du sol purent contempler les profils de *terra-rossa* ou terres rouges qui forment un des principaux types intermédiaires entre les podsols et les latérites.

Comme chez les podsols, l'horizon A de ces *terra-rossa* est fortement délavé et a une tendance à prendre une texture de plus en plus grossière tandis que l'horizon B s'enrichit en matériaux fins, qui en augmentent la compacité, ce qui se manifeste par une teneur toujours beaucoup plus élevée en $Al_2O_3$ et $Fe_2O_3$ dans l'analyse chimique.

Donnons, à titre d'exemple, l'analyse chimique des horizons A, B et C d'un profil de *Georgeville silt loam* qui fut examiné aux environs de Greensboro, (Caroline du Nord) lors d'un arrêt du train spécial du Congrès de la Science du sol, l'an dernier:

| Horizons | $P_2O_5$ | $K_2O$ | CaO | MgO | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | $Na_2O$ |
|---|---|---|---|---|---|---|---|---|
| A | 0.07 | 1.18 | 0.57 | 0.41 | 80.32 | 8.50 | 3.23 | 1.55 |
| B | 0.07 | 1.30 | 0.32 | 0.74 | 55.28 | 23.94 | 9.08 | 0.30 |
| C | 0.04 | 3.98 | ..... | 0.98 | 69.09 | 16.47 | 4.92 | 0.36 |

Mais sous l'effet de la température chaude et humide des longs étés —en Caroline et en Géorgie la chute annuelle atteint et dépasse 50 pouces —l'altération des silicates est déjà beaucoup plus énergique et plus profonde que dans notre pays à courte saison estivale et aux longs hivers.

Le fer des silicates est très énergiquement oxydé et forme, à la surface du moins, des oxydes ferriques moins hydratés que la limonite de nos latitudes, tels que la surgite, et selon certains auteurs même de l'hématite rouge ou oligiste, qui communiquent aux sols cette teinte d'un rouge brun très accentuée.

Habitués que nous sommes, dans la province de Québec, à des sols d'origine glaciaire dont la roche mère est relativement peu altérée sous les basses températures à laquelle elle se trouve exposée, ce qui nous frappe vivement aussi dans des régions comme la Caroline ou la Géorgie, qui n'ont pas connu la glaciation quaternaire, c'est d'y trouver des roches éruptives, telles que des granites, transformées en place sur une épaisseur de 15, 20 pieds et davantage, en cette terre rouge.

## Conclusion

Cet exposé est nécessairement très sommaire et incomplet. Mais nous pensons qu'il aura été suffisant pour démontrer qu'il faut tenir compte de la grande variabilité du facteur climat dans l'étude de la genèse des sols, et que ce facteur est très important dans leur classification.

Loin de diminuer l'importance du facteur géologique cependant, l'introduction du facteur climat dans la classification ne fait qu'en préciser la portée.

C'est en tenant compte de ces deux facteurs, sans négliger quelques autres qui peuvent devenir prépondérants dans des circonstances spéciales, mais dont nous n'avons pas eu le temps de parler, qu'on acquiert la véritable philosophie des connaissances du sol, qu'on arrive â coordonner et à généraliser une foule de notions isolées concernant les sols.

Ainsi la seule description du type podsol résume en elle les besoins fondamentaux de nos sols des régions tempérées humides, auquels on a affaire dans la province de Québec: Sols en voie de décrépitude, par suite du délavage de leurs électrolytes, ils s'appauvrissent aussi en colloides non saturés et perdent leur pouvoir absorbant.

Une opération fondamentale de restauration pour tous les sols fortement podsolés doit-donc être leur réapprovisionnement en électrolytes, par l'introduction d'amendements calcaires. D'autre part, l'étude des modifications morphologiques dues aux variations de climat dans l'évolution des sols fournit aussi une explication naturelle de ces différences de texture et de structure que l'on observe aux divers niveaux et qui sans cela étaient une énigme.

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## Notes

Nous adressons nos bien sincères félicitations au confrère Damase Belzile, Secrétaire de la Section de Québec, à l'occasion de sa nomination en qualité d'Assistant surintendant des champs de démonstration à la Ferme expérimentale d'Ottawa.

On sait que monsieur Belzile occupait jusqu'ici la position d'Assistant surintendant des fermes de démonstration de la province de Québec.

Signalons plusieurs réunions de sections qui ont eu lieu au cours des derniers temps.

Le 15 novembre, à 7 h. p.m., la section de Québec organisait un diner-causerie au restaurant Kerhulu, à Québec, Le conférencier fut monsieur L. Ph. Roy, Chef du Service de la Grande Culture, qui prit comme sujet: "Le problème agricole chez nous". Assistait en qualité d'hôte d'honneur, l'honorable L. Lapierre, ministre sans portefeuille et député de Mégantic. Le banquet présidé par le confrère Geo. Maheu, réunit une cinquantaine de convives et fut des plus réussis.

La section de Ste-Anne de la Pocatière organisait un goûter-causerie à l'école d'agriculture, le 12 décembre, à sept heures et demie du soir. Monsieur Georges Bouchard, M.P., de retour d'Europe, où il avait représenté le Canada au Congrès international des Arts populaires, fut le conférencier du jour. Il prit comme titre de sa causerie:" Quelques impressions d'un congressiste au retour de la Tchékoslovaquie."

## CONCERNING THE C.S.T.A.

The attention of members is directed to the fact that applications for the five 1929 T. Eaton Company scholarships of $600 each must be in the hands of the General Secretary not later than May 15, 1929. These scholarships are tenable at any Canadian university offering graduate courses in agriculture, and were officially advertised on the back cover of the December issue of this journal. Regular application forms may be obtained from the General Secretary.

Members who have not yet received their 1928-29 membership cards should send their renewal fees to their local secretary without further delay.

A second edition of the C.S.T.A. "Who's Who", published in 1924, will be prepared early in 1929, in the hope that it can be issued in May next. It will contain the biographies, academic training and professional experience of well over 1,000 technical agriculturists and should be a valuable reference book.

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The letter addressed by Dr. E. S. Archibald, President of the Society, to each local secretary, and published in the last issue, has resulted in a number of interesting meetings and much useful discussion. The Macdonald local held a preliminary meeting on December 13th, devoted chiefly to the questions of group organization and agricultural policy. Committees were appointed to bring in resolutions at another meeting to be held early in January. The Eastern Ontario local will hold a series of three debates (one each in January, February and March) based upon the last report of the Committee on Agricultural Policy and dealing with the three following phases of the report: (1) Education, (2) Publicity, (3) Research.

The British Columbia local conducted its fall meeting, held during the last week in November, on the group plan. Separate meetings were held on the following subjects: (1) Plant Pathology, (2) Horticulture, (3) Animal Husbandry, (4) Agronomy. The group meetings were followed by a general session and a dinner. All meetings were exceptionally well attended. In commenting upon it the President of the local writes: "The group plan of organization met with entire approval and as a result of it the B.C. branch is away to a new lease of life. We have only 85 members in the province and in checking up the attendance at the different meetings, we find that the greater percentage of the members were in attendance at some time or other. This has never been possible before."

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### Notes and News

J. D. Belzile (Laval '20) formerly Assistant Superintendent of Demonstration Farms in the Province of Quebec, which position he has held for six years, has been appointed Assistant to Chief Supervisor of Illustration Stations in the Experimental Farms Branch of the Dominion Department of Agriculture, Ottawa.

J. C. Steckley (Toronto '11) has been advanced from Associate Professor of Animal Husbandry to Senior Professor of Animal Husbandry at the Ontario Agricultural College, Guelph, Ont. With this promotion comes similar advancement for G. E. Raithby (Toronto '22), formerly Lecturer now Junior Associate Professor of Animal Husbandry.

A. G. Gilbert (Laval '23) has changed his address to 124 Percy Street, Ottawa, Ont.

A. S. Kyle, who is agent in Los Angeles, California, for the Petersime Incubator Co., is now located at 2931 Flower Street, Walnut Park, Los Angeles, Cal.

Gordon Stuart Matthews (McGill '24) died in the College Hospital connected with the Michigan State College on December 5, 1928. He had been taking post graduate work and was admitted to the hospital about two weeks before his death. He was born at Lachute, P.Q., in 1901.

J. A. Carroll (Toronto '14) who has been Assistant Director of Agricultural Representatives in the Ontario Department of Agriculture since 1924 has received the appointment of Director of the Co-operation and Markets Branch in succession to F. C. Hart.

J. C. Neale (Toronto '17), Associate Editor of the *Ontario Farmer* since 1925, has joined the staff of the James Fisher Company, advertising agents, Toronto.

C. H. Hodge (McGill '14), Live Stock Editor of the *Family Herald & Weekly Star,* Montreal, has been appointed Associate Editor of the *Ontario Farmer,* Toronto.

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### Applications for Membership

The following applications for regular membership have been received since December 1, 1928:—

Atkins, E. W. (Manitoba, 1928, B.S.A.) Winnipeg, Man.
Bennett, J. C. (Toronto, 1923, B.S.A.) Chatham, N.B.
Hand, J. Albert, (Toronto, '05), Toronto, Ont.
Martin, Alphonse (Montreal, 1928, B.S.A.) Plantagenet, Ont.

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New members who join the Society during the remainder of the Society year should pay the regular initiation fee of $5.00 and 50 cents per month up to May 31st, 1929. This will bring their regular annual fee of $5.00 due on June 1st, 1929. It is hoped that a considerable number of eligible members will make application for membership after the holiday season is over and the above information is furnished chiefly for the benefit of local secretaries who may be canvassing for new members.